GENERATION, TRANSMISSION AND APPLICATION OF THE POWER SERVICES • A McGRAW-HILL PUBLICATION

Power

DECEMBER
1956 • 50¢

HOW TO COMBAT CORROSION

a 36-page special report

Two ELLIOTT
5000-hp, 3600-rpm
squirrel-cage
Induction Motors

Full-load tests confirm the excellent design of

INDUSTRY'S LARGEST 2-POLE INDUCTION MOTORS

The completion of industry's largest two-pole induction motors marks another achievement of the Elliott Company. This is a field in which the Elliott Company has maintained consistent leadership since the first large 2-pole induction motor was built in 1916.

The building of these motors was made possible by extensive previous experience; now the excellence of their design is confirmed by full-load tests. Data obtained in these tests also provide the information needed to insure the success of larger motors yet to come.

The boiler-feed pump motors shown above are the latest Elliott "Super-Quiet" construction, designed to lead the way to lower sound levels demanded by noise-conscious industry today.

Send for a copy of our new booklet, "Milestones," which gives more information about these machines. Address Elliott Company, Ridgway, Pa.

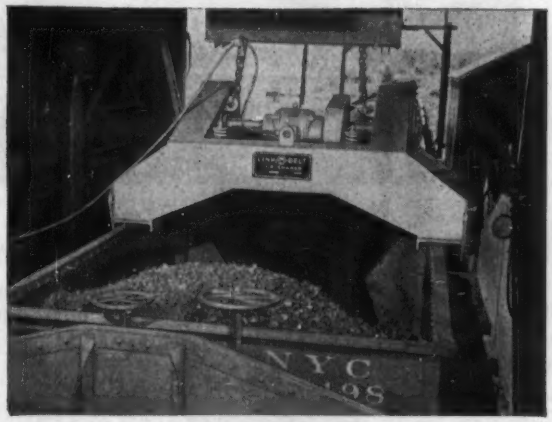
If you have not already seen these motors you are invited to attend the demonstration now being conducted at Ridgway.

ELLIOTT Company

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS
CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

JUST A MINUTE—

that's all it takes to empty a RR car with a LINK-BELT Rotary Dumper



CAR SHAKERS will unload 15 or more cars per day. One man with a Link-Belt Car Shaker can empty a car "broom-clean" in minutes.

IMPROVE your unloading with push-button emptying of gondola cars. For large operations, a Link-Belt Rotary Dumper will empty a 90-ton gondola car every 45 to 90 seconds (including return to upright position) by turning the car upside down. For smaller plants Link-Belt Car Shakers will cut unloading time, free manpower. Both are designed to handle your unloading operations faster . . . easier . . . at lower cost. Call your nearest Link-Belt representative. He'll be glad to recommend the car unloading method to suit your specific needs.

14,084

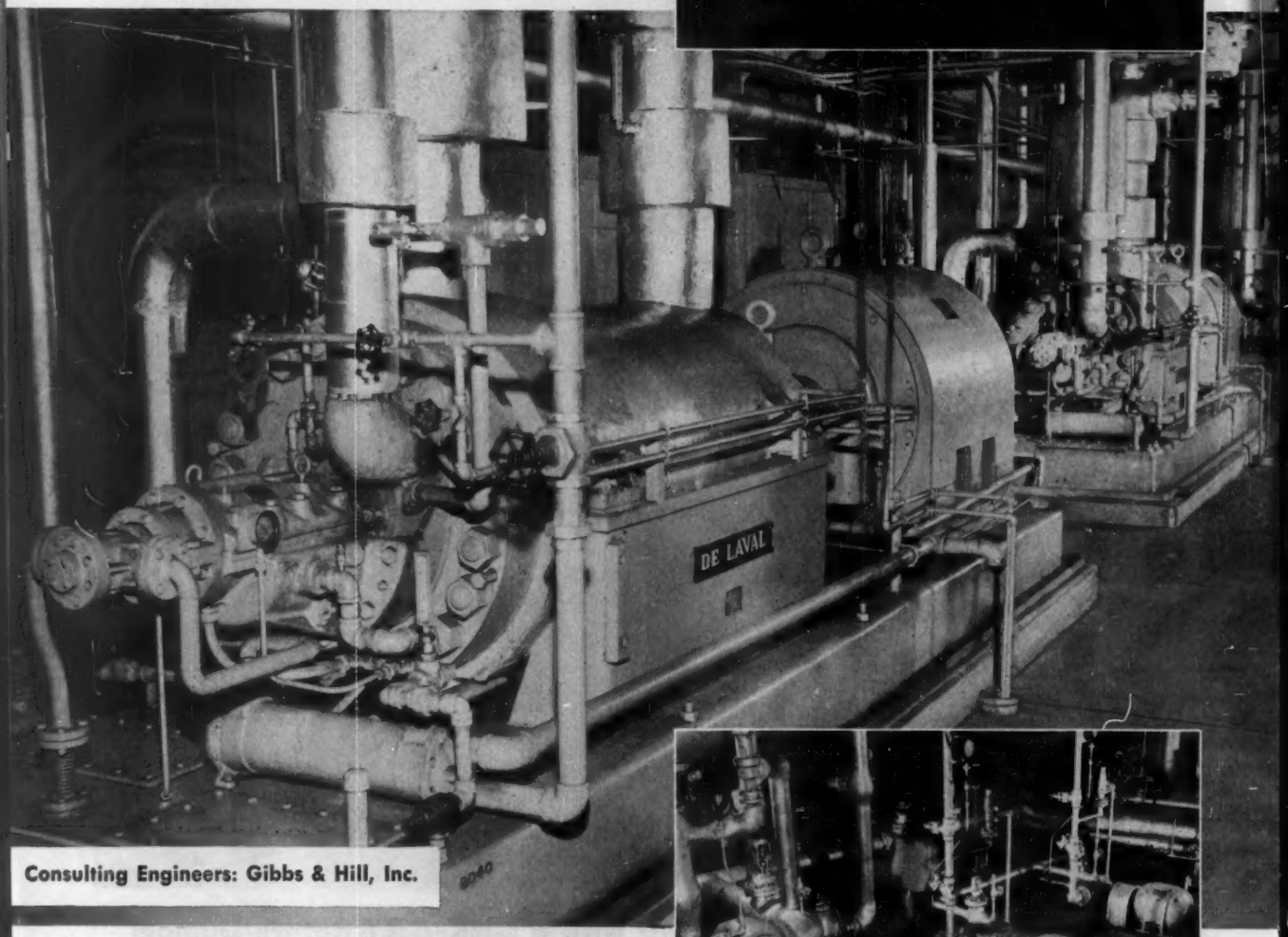
LINK-BELT

ROTARY DUMPERS and CAR SHAKERS

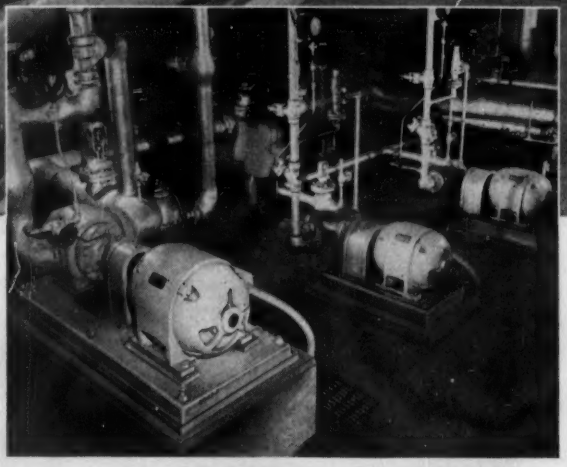
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

Atlantic City Electric ... another utility using

DE LAVAL
BARREL TYPE BOILER FEED PUMPS



Consulting Engineers: Gibbs & Hill, Inc.



De Laval IMO rotary positive displacement pumps handle heavy fuel oil. They are used for standby operation.

Atlantic City Electric Co. and Gibbs & Hill, Inc., Consulting Engineers, know that they can count on De Laval reliability. That's why they selected three De Laval high pressure barrel type boiler feed pumps for the Deepwater Station in Penns Grove, New Jersey. These 10-stage units deliver 675 gpm, operating at 1762 psi with temperature at 287 F. The pumps are driven by 900 hp motors.

De Laval barrel type boiler feed pumps operate at pressures up to 5500 psi. These units offer many important design advantages, such as double volute diaphragm, individual diaphragm bolting, only one inner high-pressure joint, and bare shaft construction. Their dependability is proven by year in, year out service in public utilities and industrial plants.

Send for De Laval Bulletin 1506, which contains helpful data.

DE LAVAL *Boiler Feed Pumps*

DE LAVAL STEAM TURBINE COMPANY
815 Nottingham Way, Trenton 2, New Jersey

Power

DECEMBER 1956 • VOLUME 100 NUMBER 12

ENGINEERING AND MANAGEMENT

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WAR ON CORROSION has increased its tempo during the past 7 years. And as part of our normal editorial diet, problems and progress have found their way to POWER's pages. Current special report, p 73, wraps up the latest thinking—from theory of corrosion to mechanics of setting up an effective control program.

This month's cover depicts, with much artistic license, one portion of the corrosion picture: techniques for combating it.

Next month . . .

High-temperature water systems in central heating plants have shown some fundamental advantages over high-pressure steam. And the U.S. Air Force is installing the scheme in many new bases. January 4-pager, first of a 2-part article, carries the details.

Big maintenance job in caring for transformers centers about the oil or askarel. One trouble area is gasketed seals—they must lock in fluid, lock out moisture, other contaminants. Coming article shows how to handle gasket replacement.

Boiler casings and settings develop air leakage spots due to constant expansion, contraction. Detecting these leaks has been a time-consuming job. Now a fast, safe way to pinpoint leaks uses a phosphate ester fog as a ferret. Developed for boilers, it's a natural for condensers too. Watch for this 2-pager.

. . . and future months

If figuring combined performance of steam turbines, surface condensers is up your alley, don't miss Feb issue!

December 1956 POWER Vol. 100—No. 12

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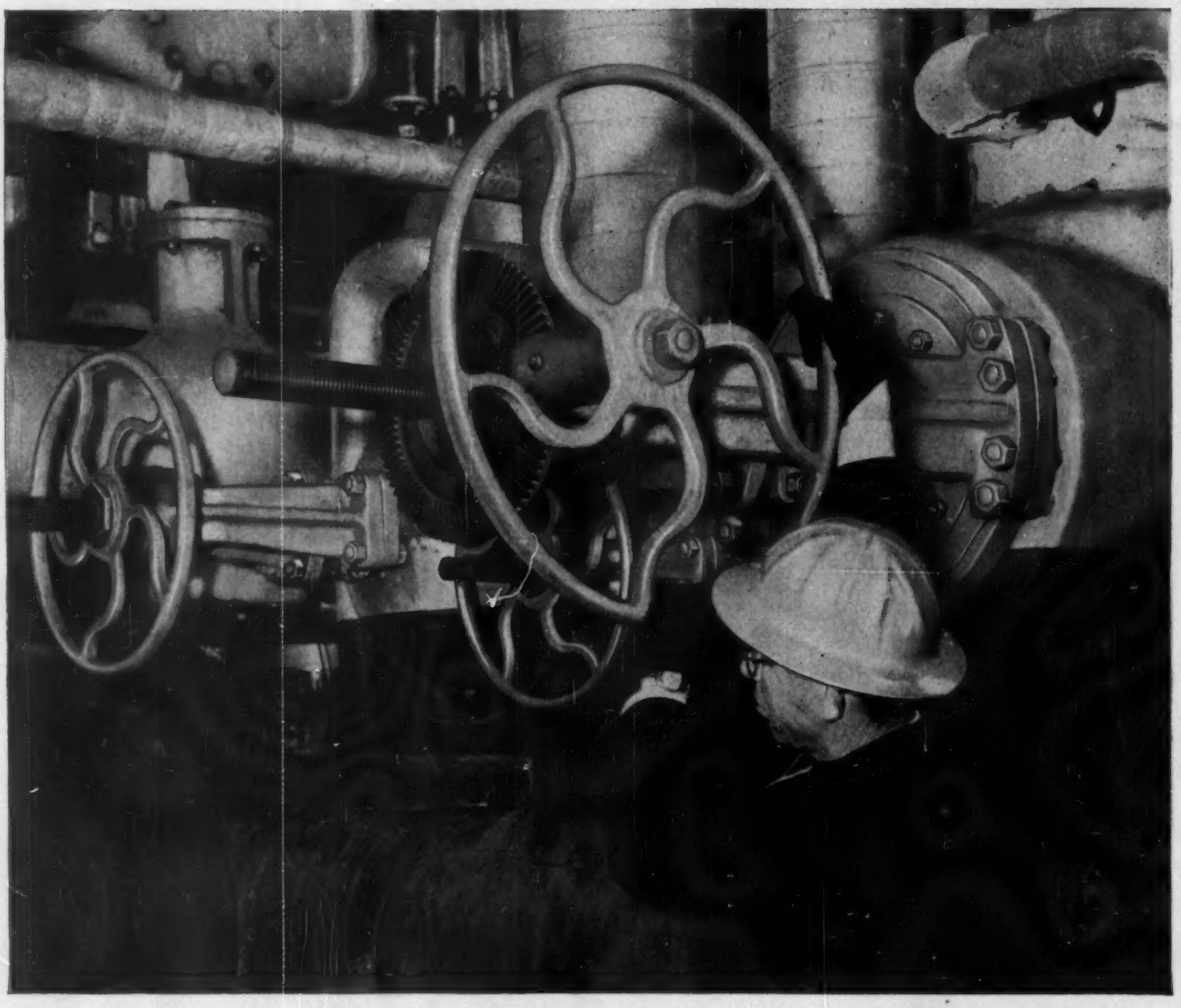

12 years' cost-free service completed by this Crane valve on saturated steam

Since 1944, this Crane 16-inch Pressure-Seal gate valve has been handling 450 psi saturated steam. It's working as a stop valve on a header in the Neches Butane Products Company's butadiene plant in Texas.

When opened for inspection recently—after 12 years of hard service—this rugged Crane valve was found to be in perfect condition. Not once has it leaked or needed maintenance at the bonnet joint or seat.

Here's why: instead of depending on bolting to retain pressure, the Crane Pressure-Seal bonnet design utilizes internal fluid pressure to make a leak-free, maintenance-free joint. And with the Crane flexible wedge disc—self-adjusting to temperature changes—sticking of the disc is eliminated, and operation is always smooth and easy.

Because they're so trouble-free, and so compact and streamlined (saving line weight and simplifying insulation), Crane Pressure-Seal Bonnet Valves are giving consistent satisfaction on high-pressure, high-temperature power plant service. Get full information from your local Crane Representative, or write to address below.

CRANE VALVES & FITTINGS

PIPE • KITCHENS • PLUMBING • HEATING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

speaking of **Power**

RECEIVING: Ralph Zimmerman of MPA presents Assoc Ed Steve Elonka with plaque for editorial work in field of seals

GIVING: Lou Rowley, right, hands '55 *Power* Citation to N Nordal of Bridgeman-Russell; J L McEachin of M P&L, center

Editorial honors prove a two-way operation for *Power* staffers

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B G A SKROTZKI *Engineering and Management*
S M ELONKA *Operation and Maintenance*
T G HICKS *Special Projects*
J J O'CONNOR *Managing Editor*
H P KALLEN *Associate Editor*
R C BELLAS *Assistant Editor*
N PEACH *Assistant Editor*
A P SOMMER *Assistant Editor*
A S THORNTON *Assistant Editor*
C F MARSCHALEK *Art Editor*
F A ANNETT *Contributing Editor*

P W SWAIN *Consulting Editor*

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Receiving bouquets, either from readers or industrial groups, is a mighty pleasant part of an editor's job. They serve, along with the brickbats, to keep tabs on readers' current wants.

Mechanical Packing Association recently bestowed kudos, in the form of an elegant gold-plated plaque, on Associate Editor Steve Elonka for his series of practical manuals on seals. Over the years Steve's work has grown into a comprehensive library on piston rings, gaskets, mechanical packing and mechanical seals. The complete series, as it appeared in POWER, is available in reprint form.

Plaque presentation to Steve was made by Ralph Zimmerman at Skytop Club, Skytop, Pa. There is this added distinction connected with the plaque-giving: it is the first time in the 23-yr history of the Association that an editor has been so honored.

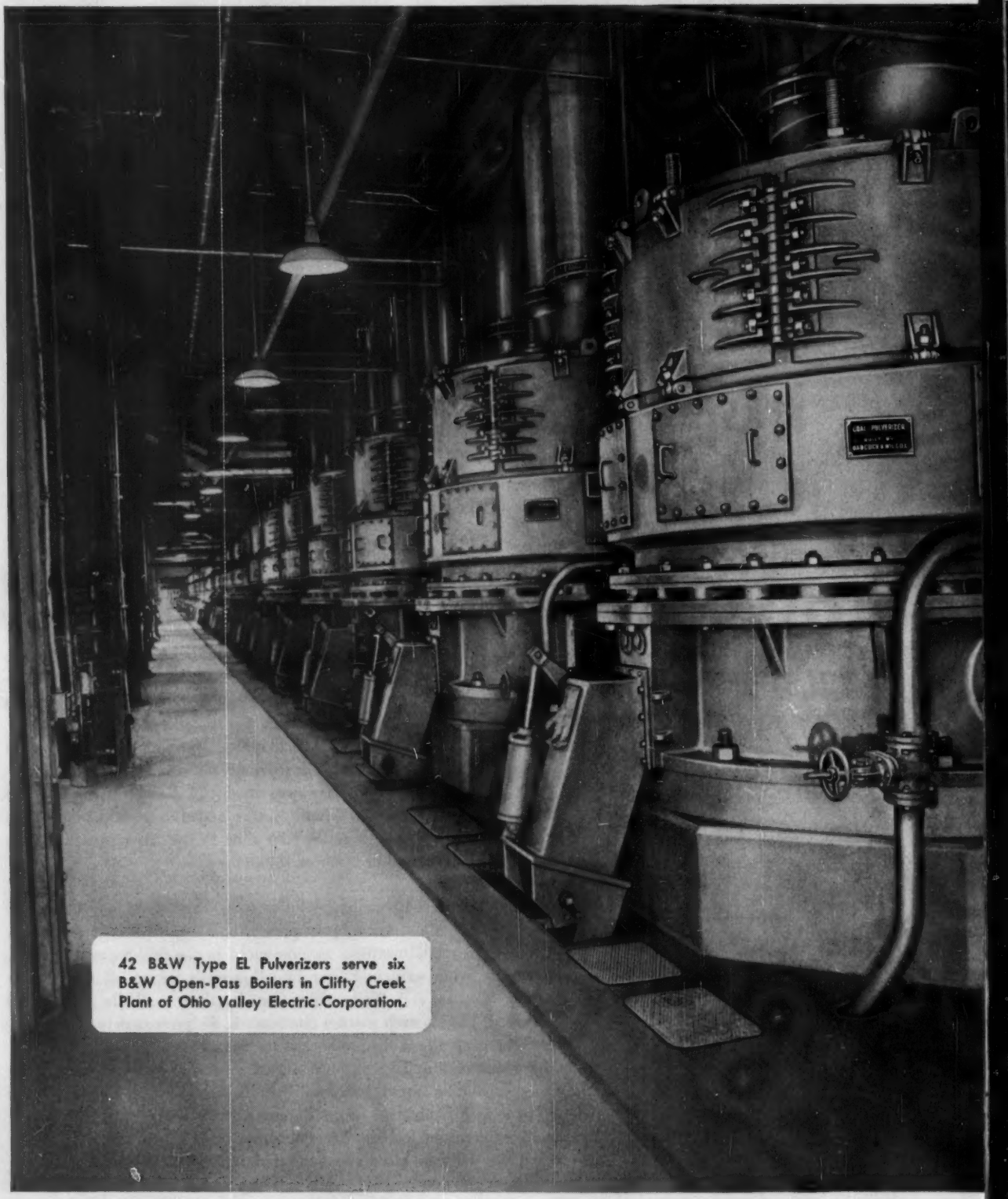
Giving bouquets is our happy lot as well. Right now our editors are busy traveling about the country presenting POWER's Citations for successful plant modernizations as announced in the mid-September issue. As this is being written, Editor Lou Rowley is taking off on a swing through Ottawa and Walkerville, Canada, then to Wells, Minn. and Rockford, Ill. At each plant a citation will be presented to plant management, generally in the presence of the consultant.

Associate Editor Ben Skrotzki picked a sweet assignment in the citation-presentation circuit. Ben will handle the honors at Florida Power & Light in Miami, then fly to Puerto Rico to study growth in power facilities as related to *Operation Bootstrap.*

All this will take place about the time most of us will be digging our way through snow and ice, while nursing a cold to boot.

Have You Investigated

THE MODERN B&W



42 B&W Type EL Pulverizers serve six B&W Open-Pass Boilers in Clifty Creek Plant of Ohio Valley Electric Corporation.

DIRECT-FIRING SYSTEM?

A Compact, Space-Saving Package of Efficient Grinding Power

More power and capacity in a compact arrangement . . . long-range dependability . . . reduced operating cost — these are the measurable results of continuous, intensive development of the modern B&W Pulverizer. It has established an outstanding production and efficiency record in thousands of commercial installations. Here are some reasons why:

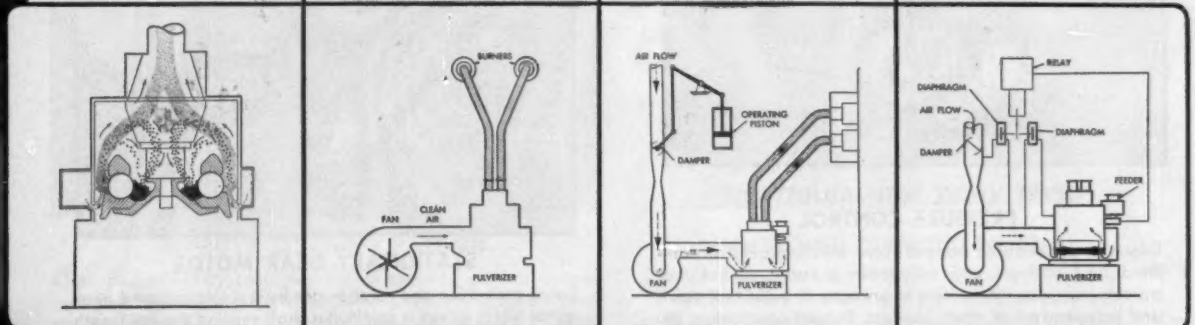
Continuous High Fineness Over Entire Service Life: Efficient combustion requires high fineness at all times. The high circulating load of the B&W Pulverizer permits efficient and dependable classification of product, so that only material of proper fineness leaves the unit. In addition, its slow-speed, spring-loaded ball bearing grinding elements maintain proper grinding contact throughout their service life.

Handles Wide Variety of Low Grade and Wet Coal: Regardless of the coal's grade or whether it's dry or soaking wet, the B&W Pulverizer's unique and exclusive recirculation of fuel through heated air assures efficient grinding . . . eliminates shutdown, capacity loss, or special attention from operators.

Simplicity of Arrangement and Reduced Maintenance: Accessibility for all normal maintenance makes it simple, quick, safe and low-cost. Adjustments are easily made while the unit is in operation. Using only clean primary air supplied under pressure, fan maintenance is substantially reduced and fuel piping is greatly simplified. Also, with the pulverizer acting as its own distributor, no special distributing devices are needed. Grinding elements are of special alloy material. They last two years or more on eastern coals and at least a year on midwestern coals.

Adaptable to All Types of Automatic Controls: Because it features "one point contact with the boiler," operation of the B&W Pulverizer is simple. The boiler's automatic combustion control is connected to the pulverizer at only one point—the damper in the primary-air duct. The pulverizer's own control system regulates all other functions, such as maintenance of proper fuel-air ratio and operating temperature.

SEND FOR DATA. For full information about the B&W Type EL Pulverizer and Pulverized-Fuel Firing Systems, write: The Babcock & Wilcox Company, 161 E. 42nd Street, New York 17, N. Y.



COAL RECIRCULATION — this means high fineness, aids drying.

PRESSURE SYSTEM — this eliminates fan wear, simplifies piping.

AIR CONTROL—this means one, simple control contact point.

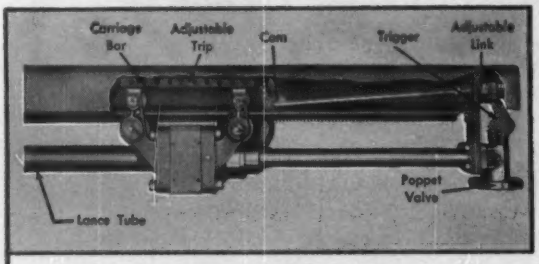
MILL LEVEL CONTROL — this automatically adjusts fuel-feed.

BABCOCK & WILCOX

BOILER DIVISION

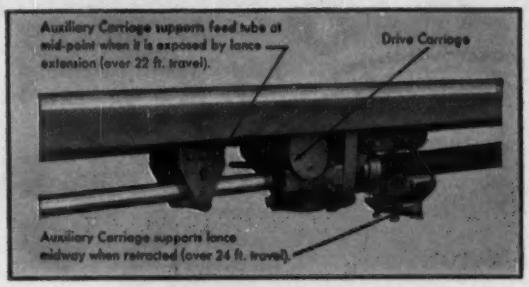
G-766

Introducing DIAMOND SERIES 300 IK



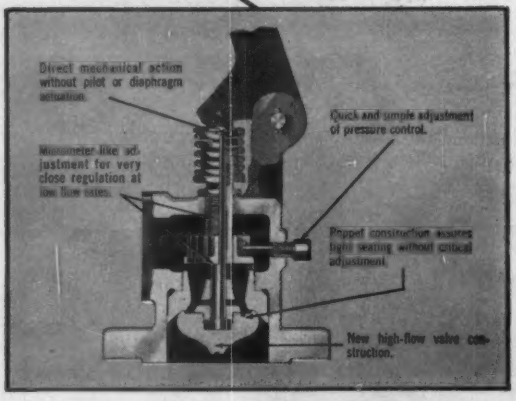
MECHANICALLY OPERATED VALVE

Control of blowing medium is automatic, positive and accurate by means of a simple, dependable mechanically operated valve. As lance begins movement into boiler, trip on carriage opens valve through a linkage. At end of retraction, trip closes valve. All pilot or diaphragm valve elements are eliminated. Trip is adjustable.


Auxiliary Carriage support feed tube at mid-point when it is exposed by lance extension (over 22 ft. travel).
Drive Carriage
Auxiliary Carriage supports lance midway when retracted (over 24 ft. travel).

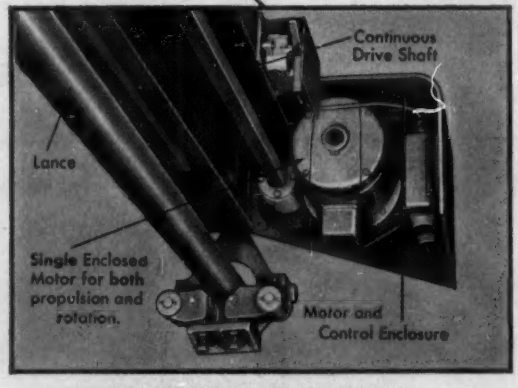
AUXILIARY CARRIAGES (FOR EXTRA LONG TRAVEL)

On extra long blowers, one auxiliary carriage supports lance midway when retracted, preventing undue bending. Second auxiliary carriage is dropped at mid-point to support feed tube when it is exposed by lance extension.


Direct mechanical action without pilot or diaphragm actuation.
Micrometer-like adjustment for very close regulation at low flow rates.
Quick and simple adjustment of pressure control.
Poppet construction assures tight seating without critical adjustment.
New high-flow valve construction.

POPPET VALVE WITH ADJUSTABLE PRESSURE CONTROL

Diamond dependable poppet valve with improved streamlined flow contours and adjustable pressure control that permits easy, accurate setting of pressure at individual valve and independent of other blowers. Poppet construction assures tight seating without critical adjustment. Stem, seat and disc are stainless steel. Stellited seating surfaces are available.



STATIONARY GEAR MOTOR

Lance propulsion and rotation are by a *single* enclosed gear motor which drives a continuous shaft running the full length of blower and providing power to carriage. This construction makes it possible to mount motor in a fixed position at the front end for better protection and accessibility.

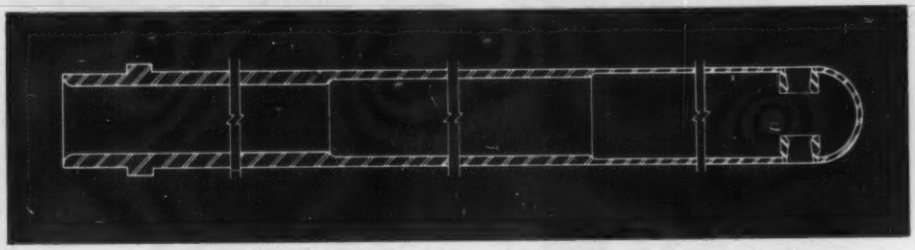
7594

DIAMOND POWER

LONG RETRACTING BLOWER

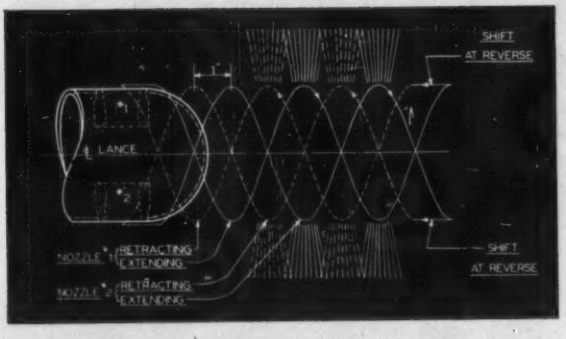
The Diamond Series 300 IK Blower sets a new and higher standard of efficiency, economy and dependability in the cleaning of heating surfaces that require a long retracting lance type blower. Pointed out in detail are some of its important features. Others are a *single* outboard support point to simplify installation and the attractive "backbone" cover for greater rigidity and protection of the entire blower assembly from dirt, damage, the elements and personnel hazards.

This new Series 300 IK is the culmination of more than 20 years' experience building and applying long travel blowers. It well illustrates the Diamond design philosophy: *"Keep it simple . . . keep it basic . . . avoid unnecessary complications."* It is further evidence of the fact that YOU CLEAN BOILERS BETTER AND AT LOWER COST WITH DIAMOND BLOWERS.



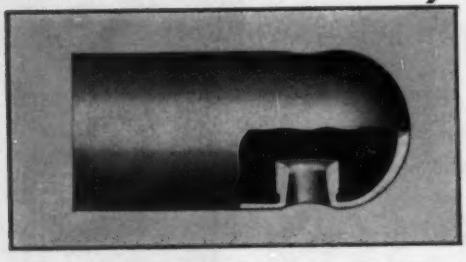
STEP-TAPER LANCE (FOR EXTRA LONG TRAVEL)

Extra long lance has minimum droop due to step-taper construction which employs up to four different wall thicknesses. Lightest wall is at nozzle end to reduce bending moment. Lance is chrome alloy for heat resistance.



IMPROVE CLEANING PATTERN

Close and positively controlled helical cleaning pattern assures maximum cleaning effectiveness. Blowing pattern diagram illustrates how return travel path is exactly intermediate with forward travel path so that there is a *positive nozzle sweep every inch.*

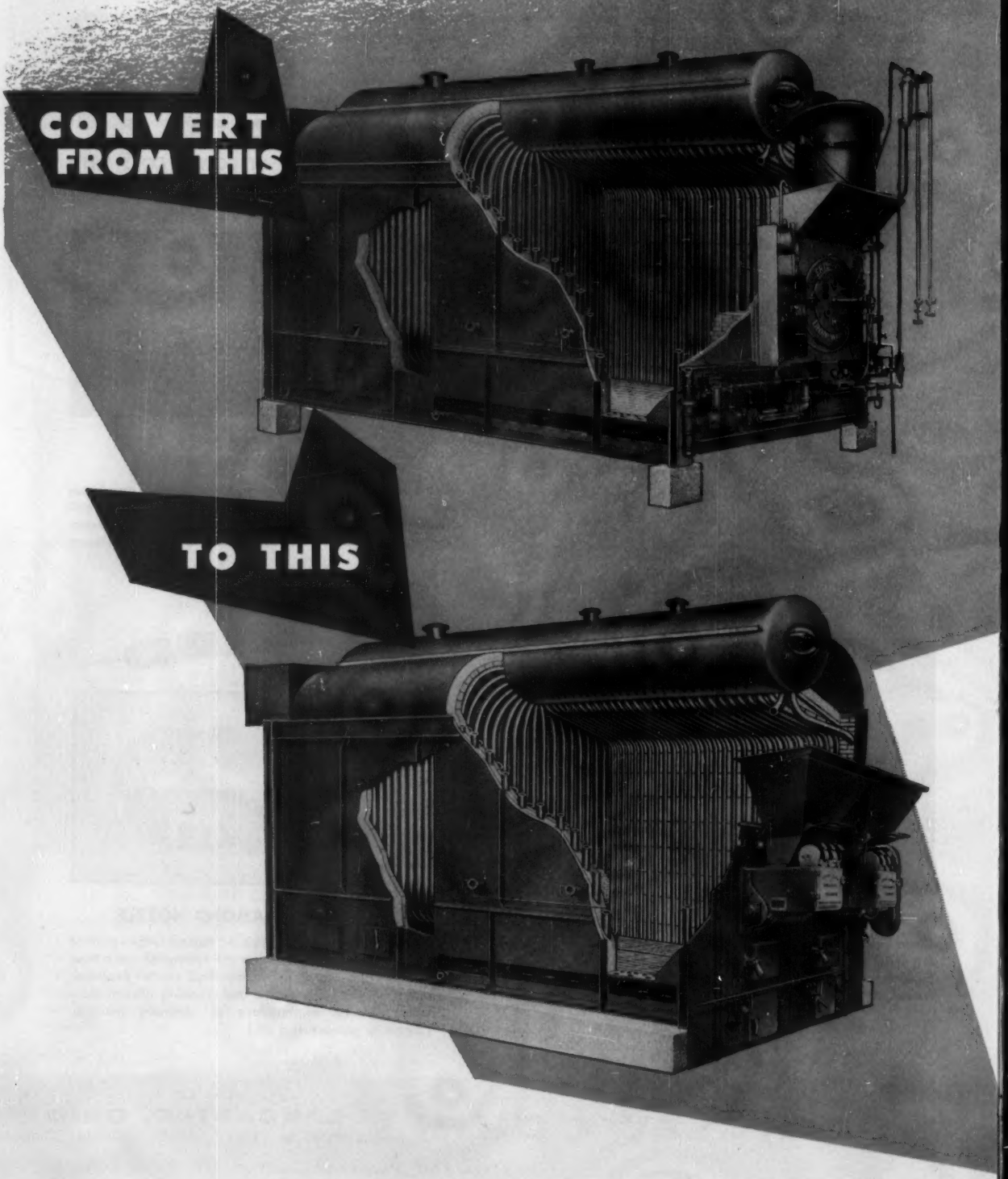


IMPROVED DIAMOND NOZZLE

New design Diamond "Type A" Nozzle is the result of several years' research and the testing of more than 50 different contours. The modified venturi produces maximum impact pressure and cleaning effectiveness with minimum expenditure of cleaning medium. (Steam or compressed air.)

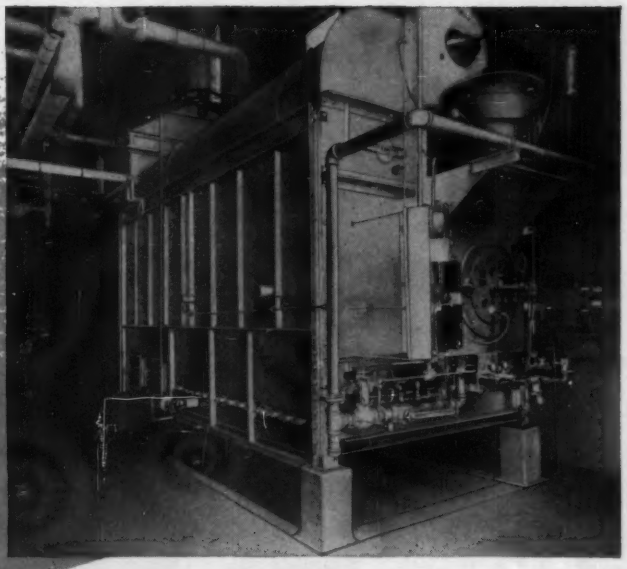
SPECIALTY CORP. **LANCASTER, OHIO**
DIAMOND SPECIALTY LIMITED—Windsor, Ontario

ERIE CITY



Packaged Boiler

OIL GAS *or* COAL FIRED



At Charleston Linen Service, Charleston, West Virginia, this Erie City 14,000 lbs/hr. VLP is now fired by Erie City oil and gas burner and will accomodate future stoker firing.

Is your plant ready to install a new package boiler? - - Then look to Erie City for the greatest range of sizes for all types of firing.

Your plant may be located in an area where gas, oil and coal are all available. At first you may want to fire your package boiler with gas and oil—but with the proper provision for future coal firing. The boiler for you to install is the Erie City VLP arranged for present oil and gas firing but with the furnace PROPERLY PROPORTIONED for future stoker firing. Erie City engineers will design your VLP for future conversion to either underfeed or dump grate spreader stoker. Then when you want to switch to coal firing pull out the burner and put into place the properly designed Erie City stoker. This guarantees you "undivided responsibility", for Erie City designs and manufactures a complete line of gas and oil burners and all types of stokers.

When arranged for gas and oil firing, the VLP will come complete with the most modern and effective safety controls and fully modulating, interlocked, electric controls, steam pressure actuated, guaranteeing proper fuel and air supply over the operating range of the unit.

All Erie City Package Boilers are completely factory assembled, piped, wired and Factory Tested with burner and fuel of your choice. They need only basic service connections in the field. For complete data write Dept. A.

ERIE CITY
116 Years in Steam Generation

You can depend on Erie City for sound engineering

ERIE CITY IRON WORKS • *Erie, Pa.*

STEAM GENERATORS • SUPERHEATERS • ECONOMIZERS • AIR PREHEATERS
UNDERFEED AND SPREADER STOKERS • PULVERIZERS

How to simplify

The Bailey Building Block Method enables you to simplify control problems by combining standardized measuring, transmitting, and controlling components as required.

control problems

Keep systems flexible, carry small inventory, cut maintenance cost with the **Bailey Building Block Method** of instrumentation and control.

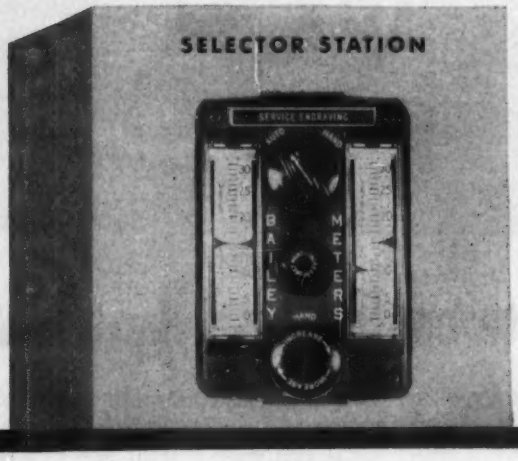
What is the Bailey Building Block Method? It's using standardized Bailey measuring, transmitting, and controlling components and combining them into any system you need. Components can be added as needed . . . removed and reused elsewhere . . . recombined into another system when the need changes. It's flexibility plus!

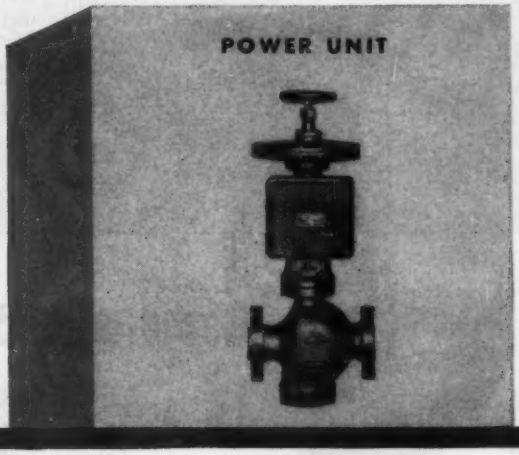
It's all based on the simple fact that a Bailey instrument or control component doesn't care if the measured variable is steam flow, tank level, or heater temperature, to pick just three examples. System components—transmitters, receivers, relays, selector stations, power units—are standardized for multi-purpose use.

A spare component can be used in any one of many systems. Gone are delays waiting for shipments of special parts. Gone are large inventories of spares and parts. Simplified is the training of men for maintenance.

There are many exclusive features and advantages of the individual components used in the Bailey Building Block Method. And there's much more to the Building Block story itself.

For further details, call our local district office or write us at Cleveland. Our engineers will be glad to prove how the Building Block approach will save you money and simplify your instrument and control problems.





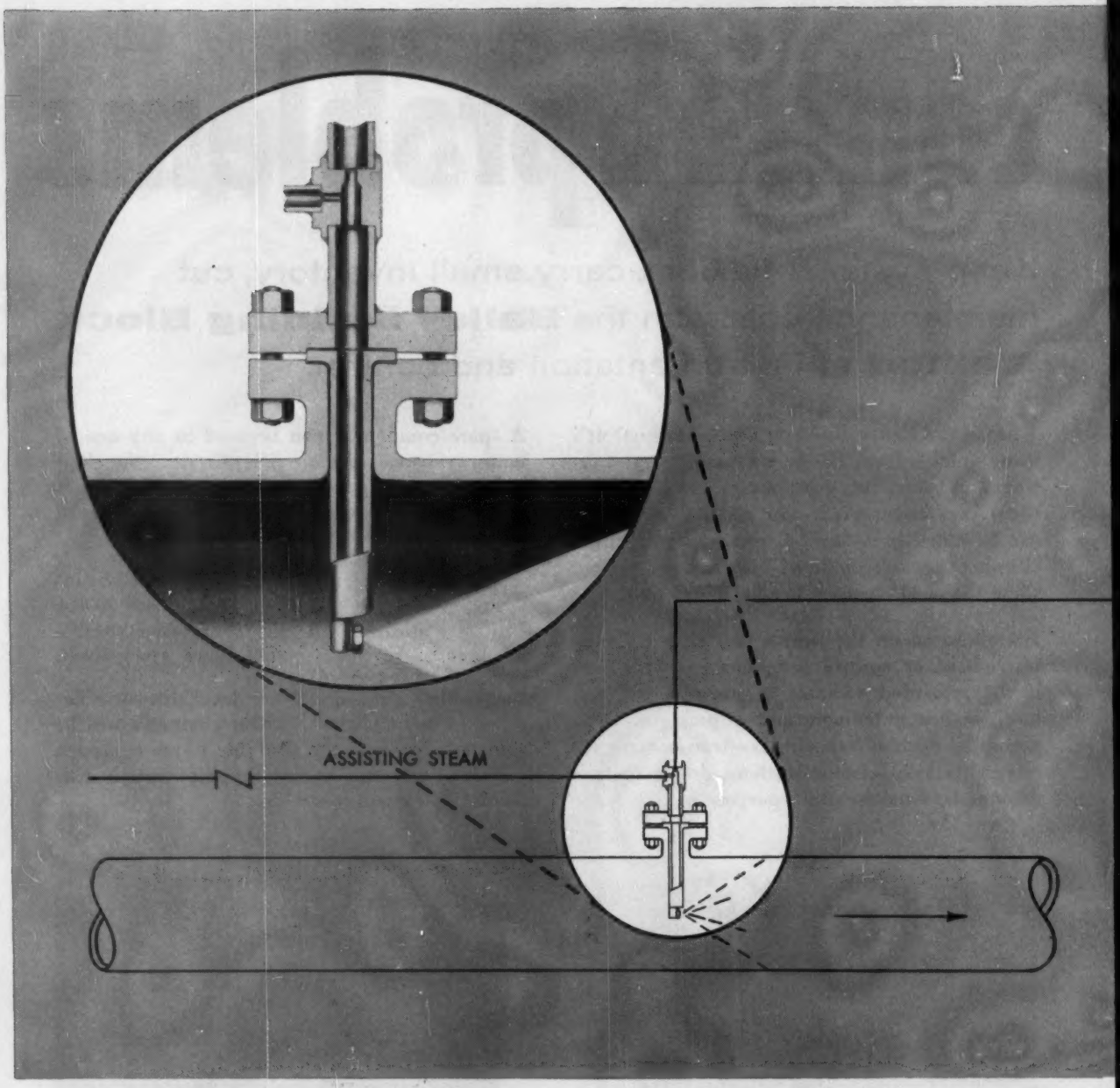
G36-2

BAILEY BUILDING BLOCK METHOD

BAILEY METER COMPANY
1036 IVANHOE ROAD, CLEVELAND 10, OHIO
In Canada—Bailey Meter Company Limited, Montreal

RESULTS IN: FLEXIBILITY, SIMPLICITY, ECONOMY

BAILEY METERS



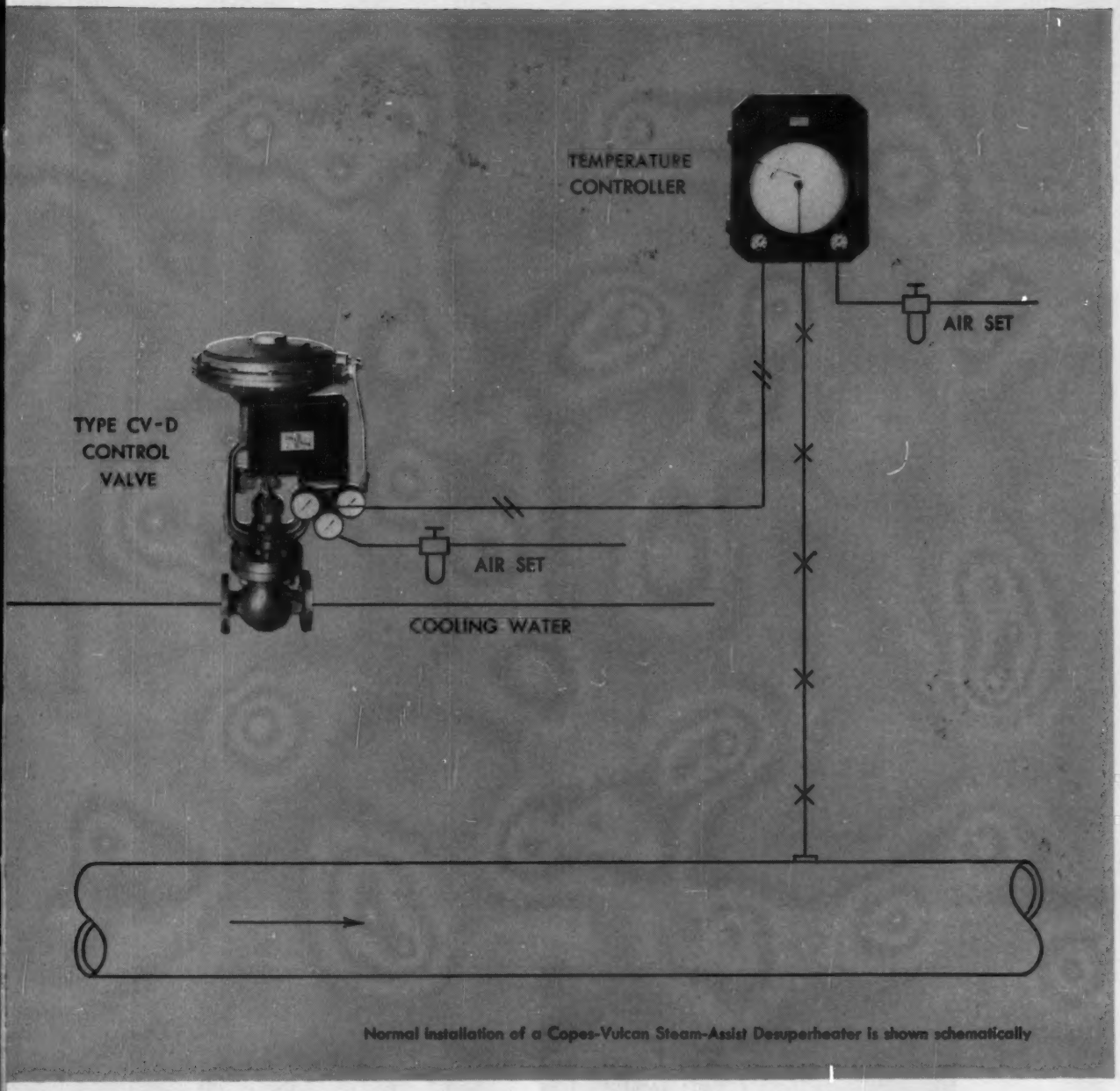
Both carburetor and in-line types are available in the new Copes-Vulcan Steam-Assist Desuperheater.

Get more accurate control with the NEW

Here is a desuperheater based on a new, proven principle that delivers more accurate control of final steam temperature for process work or auxiliaries. It uses steam only on lighter loads. As load increases, the flow of assisting steam is automatically reduced—normally without an atomizing-steam valve. Assisting steam can be off completely at high loads where no more than mechanical atomization is needed. Control is close, even at 10 degrees above saturated temperature.

Cooling water and assisting steam are intimately mixed in the exclusive Swirl Chamber—upstream from the point of injection. No large steam bubbles form to cause annoying hammer or vibration.

Incorporated into the station for close modulating control of cooling water flow is the new Copes-Vulcan Type CV-D



Normal installation of a Copes-Vulcan Steam-Assist Desuperheater is shown schematically

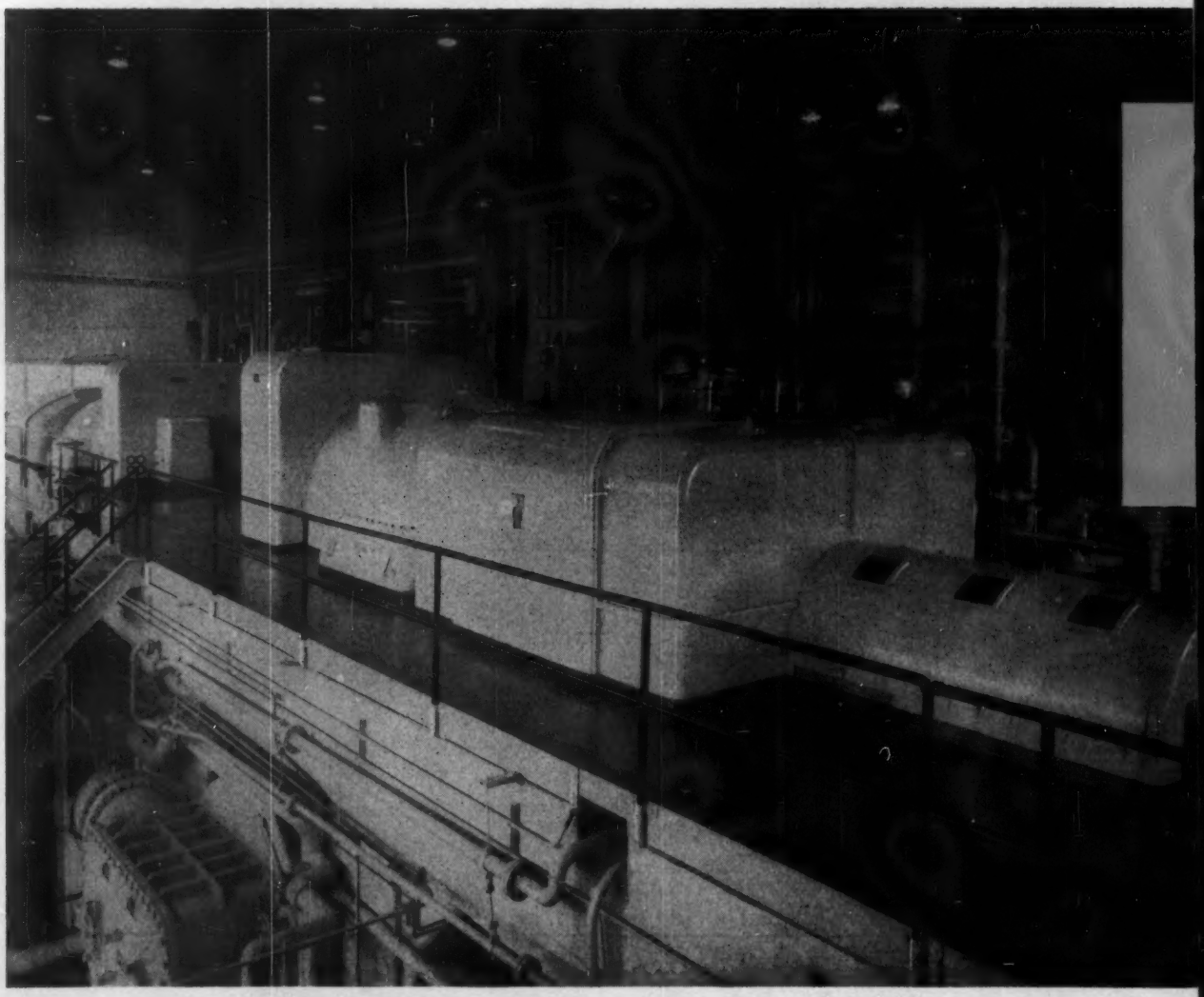
Copes-Vulcan Steam-Assist Desuperheating Station!

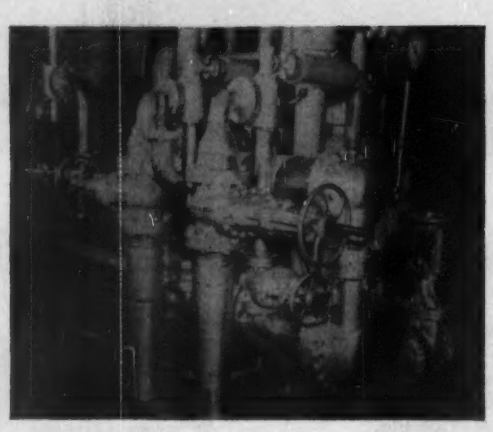
Valve. It is designed for the exact operating characteristics suited to your needs.

Enjoy the benefits of Copes-Vulcan desuperheating, custom-engineered for your individual requirements. Be sure of accurate control, minimum maintenance and long service life. Write for Bulletin 1024.

50th Anniversary
BLAW-KNOX
1906-1956

COPES-VULCAN DIVISION
BLAW-KNOX COMPANY
ERIE 4, PENNSYLVANIA





An Elliott twin two-stage steam jet ejector serves the condenser. Ejector is equipped with air leakage meter.

The forced-draft fan is driven by an Elliott C-W 150-hp, 1160-rpm motor.

ELLIOTT Company

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS
CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

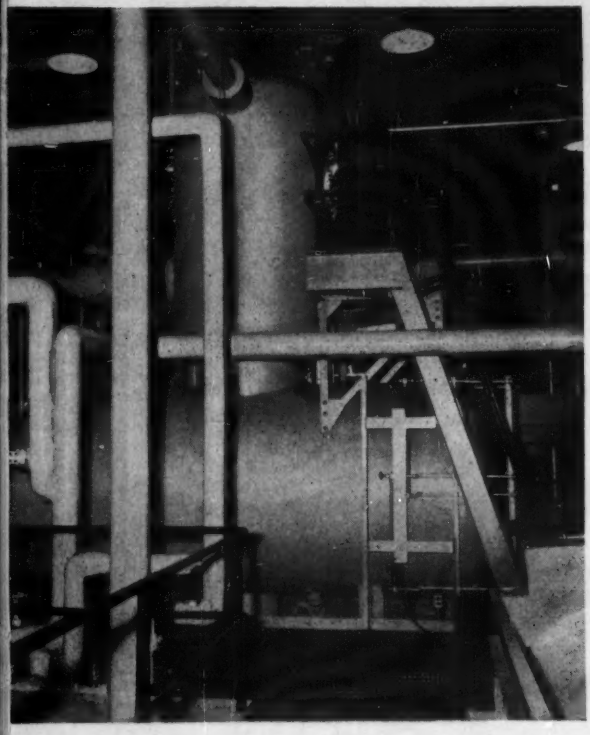
Q6-3

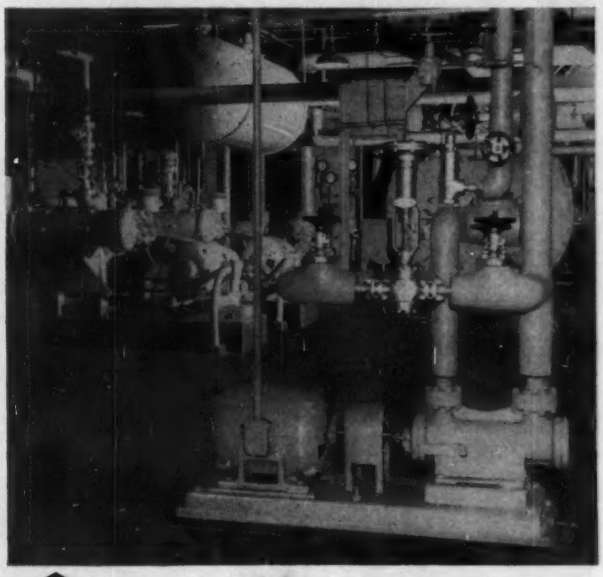
SECOND ELLIOTT UNIT installed at CARIBOU . . .

When Maine Public Service Company decided to expand the generating facilities of their Caribou Power Center, they had the benefit of four years of experience with Elliott equipment to guide them in the selection of turbine generator, condenser and auxiliaries for Unit No. 2. The equipment shown on these pages is all installed in Unit No. 2, and is evidence of the satisfactory performance of the Elliott machines in Unit No. 1.

Complete information on Elliott equipment may be obtained from our nearest District Office, or from Elliott Company, Jeannette, Pa.

This view of the turbine room shows in the foreground the No. 2 12,650-kw Elliott turbine-generator unit. Underneath it may be seen the Elliott 11,000-sq-ft surface condenser serving this turbine. Ejectors are behind the generator. In the left background is the 7500-kw Elliott turbine-generator unit installed in 1950.





The photograph above shows two air compressors driven by Elliott C-W 75-hp, 1765-rpm motors. In the foreground, the fuel oil booster pump is driven by a 15-hp, 740-rpm motor. Condenser is seen in the background.

The Elliott 128,010 lb-per-hr deaerating feedwater heater consists of a vertical heater mounted on a horizontal storage tank. It is located at an elevation near similar No. 1 unit.

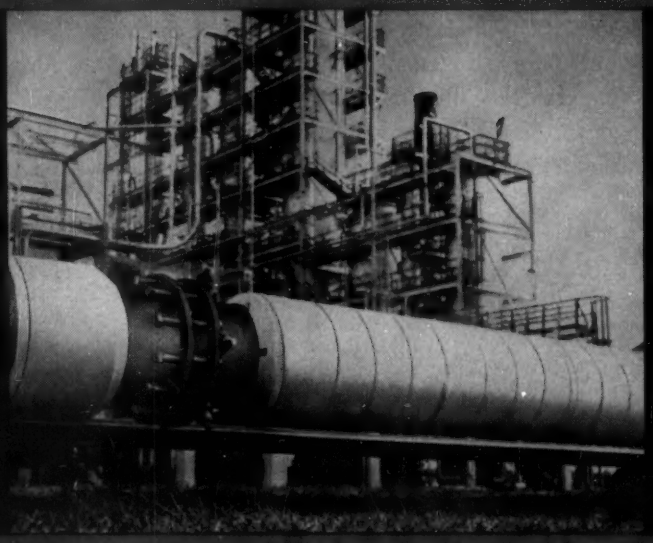
why engineers

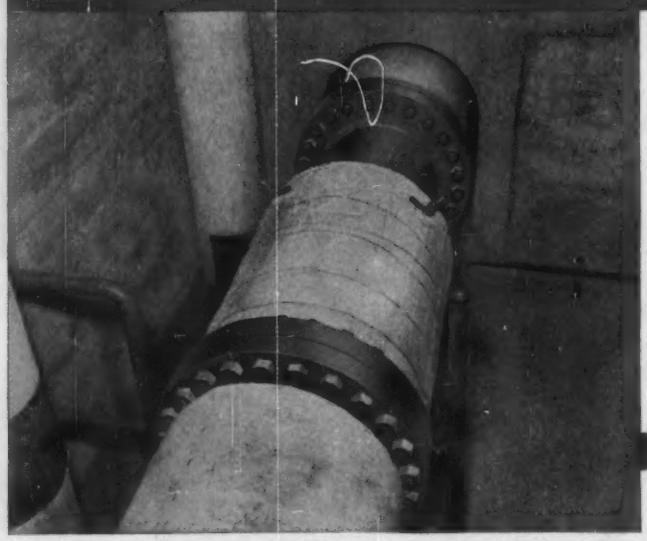
IN THE AIR...

These Gun-Pakt Joints in overhead line are some of 22 Yarway Gun-Pakt Joints installed at a large Southern hospital.

ON THE GROUND...

One of 37 Yarway Gun-Pakt Expansion Joints installed at giant oil refinery. Gun-Pakt Joints at this refinery range in size from 1½" to 14".





UNDERGROUND...

Yarway Gun-Pakt Joints installed in manhole of new steam distribution line of large Eastern utility. 12 Gun-Pakt Joints 12" and 18" are installed in this line; scores of other Gun-Pakts up to 24" are used by this utility.

YARWAY

go for Gun-Pakt Expansion Joints

■ Engineers go for Yarway Gun-Pakt Expansion Joints because:

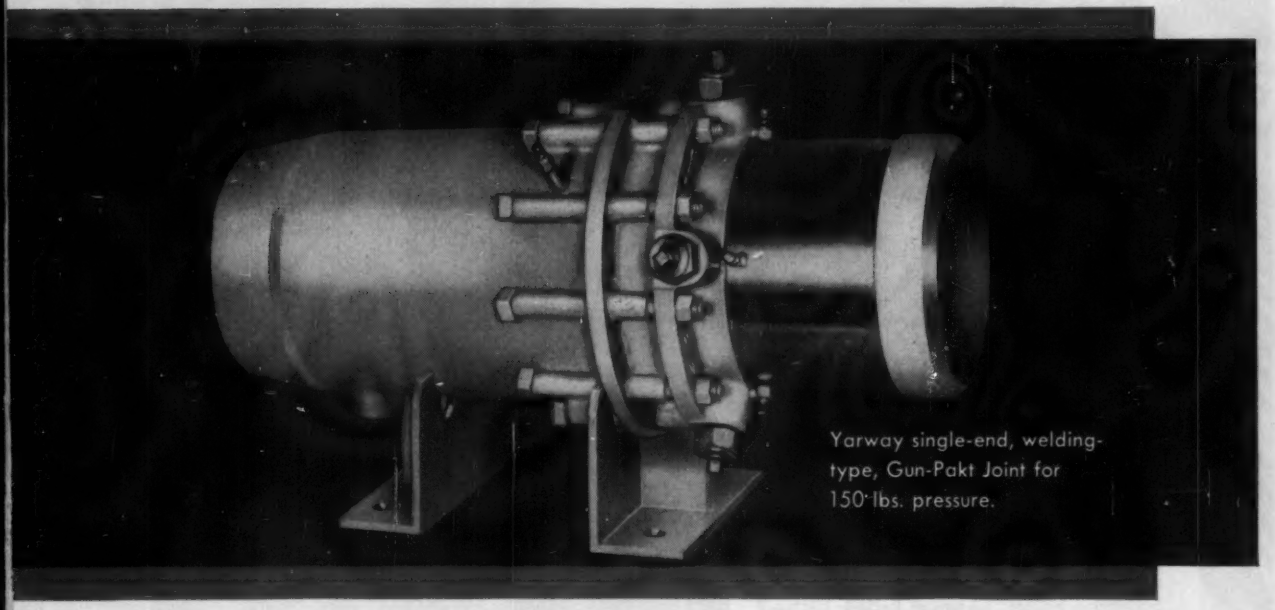
NO SHUTDOWNS. With Gun-Pakt Joints when new packing is needed, it is added under full steam pressure, right on the job—no unpacking, no shutdowns, no service interruptions.

FEWER JOINTS NEEDED. With Gun-Pakt Joints you need fewer joints per length of pipe line, with traverses up to 12" single and 24" double.

LONG SERVICE—NO METAL FATIGUE. Gun-Pakt Joints give long, trouble-free service life—no fatigue failures.

LOW MAINTENANCE. Maintenance records show the costs for servicing Gun-Pakt Joints are very low. One utility reports only 65 cents per year per joint—another reports less than half that.

Leading institutions, central heating stations and industrial plants "go for Gun-Pakt" again and again. Write now for latest bulletin EJ-1914.



Yarway single-end, welding-type, Gun-Pakt Joint for 150 lbs. pressure.

A few typical users of Yarway Gun-Pakt Expansion Joints

UTILITIES	INSTITUTIONS	INDUSTRIAL PLANTS
Detroit Edison Company	Central Heating Plant, Washington, D.C.	Ford Motor Co. of Canada
Georgia Power Company	Delaware County (Pa.) Prison	General Motors Corp. (Buick Division)
Ohio Edison Company	N.Y. Hospital & Cornell Medical Association	General Motors Corp. (Oldsmobile Division)
Rochester (N.Y.) Gas & Electric Co.	Purdue University	Westinghouse Electric Corp.
Pacific Gas & Electric Co.		
Philadelphia Electric Co.		

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Penna.
BRANCH OFFICES IN PRINCIPAL CITIES

GUN-PAKT EXPANSION JOINTS

Furnace Tubing for C-E Recovery in pulp mill is 100% REPUBLIC

GIANT RECOVERY UNIT BOILER built by Combustion Engineering, Inc., uses 80 tons of Republic ELECTRUNITE Boiler Tubing to provide 16,800 square feet of heating surface. Unit operates at 450 psi with steam temperature at superheater outlet of 750°F. Consumption is 1,610,000 pounds of dry solids per day.

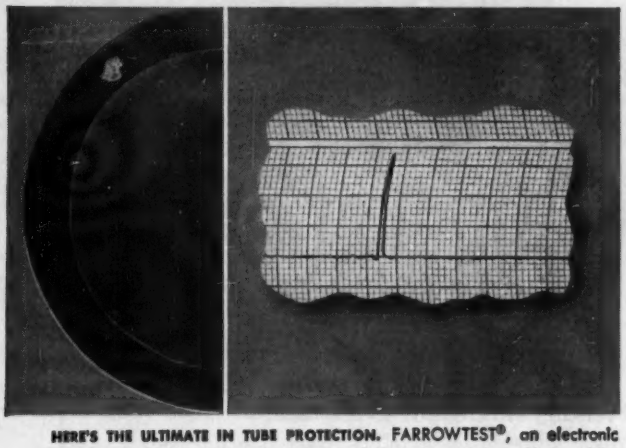
REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Unit ELECTRUNITE

UNIFORM DUCTILITY OF ELECTRUNITE Boiler Tubing helps rolling-in. Tube ends are easily and securely rolled into tube holes in drum. Result: consistently tight, weeper-free joints plus maximum ease of installation.



HERE'S THE ULTIMATE IN TUBE PROTECTION. FARROWTEST®, an electronic method of checking tubing for injurious defects, is exclusive with Republic. The oscillograph (shown above) records a defect registered on the macrograph. The presence of the defect passing through the FARROWTEST equipment automatically stops the machine, allowing the operator to mark and reject the tube. Send coupon for details.

Eighty tons, approximately 24,000 linear feet of Republic ELECTRUNITE® Boiler Tubing went into the boiler of one of the nation's largest C-E Recovery Units, recently installed for one of the South's largest pulp and paper plants.

Designed and built by Combustion Engineering, Inc., New York, the giant unit has a twofold purpose: to recover chemicals from spent liquor in the pulp mill; and to produce as much steam as possible from the boiler portion of the unit, using solids taken from the liquor as fuel. Since these functions are vital to both operation of the pulp mill and disposal of spent liquor, dependability and efficiency of the boiler are of paramount importance.

And that's where ELECTRUNITE excells.

ELECTRUNITE Boiler Tubes have a world-wide reputation for efficiency and reliability. The electric welding process, by nature, produces precise, uniform wall thickness assuring uniform, efficient heat transfer all around and throughout the length of each tube. Dependability cannot be threatened by longitudinal thin spots. Further, all ELECTRUNITE Tubes are hydrostatically or electrically tested to make certain of maximum performance in each length in any quantity.

Get all the facts on ELECTRUNITE Boiler, Condenser and Heat Exchanger Tubing from your local Republic Representative. Meantime, mail the coupon for your free copy of our handy wall chart entitled, "Care and Maintenance of Boiler Tubing." It's a handy guide to protecting your boiler installation from corrosion, erosion and physical wear and tear. Do it today.

REPUBLIC STEEL CORPORATION
Dept. C-1707
3144 East 45th Street, Cleveland 27, Ohio

Please send:
- ☐ Illustrated booklet giving facts on ELECTRUNITE Boiler Tubes
- ☐ 8-page brochure on Heat Exchanger Tubing— carbon steel ☐ stainless steel ☐
- ☐ Handy wall chart on Care and Maintenance of Boiler Tubes
- ☐ Data on exclusive FARROWTEST

Name_____ Title_____
Firm_____
Address_____
City_____ Zone____ State_____

STEEL
and Steel Products

Why Allis-Chalmers Cooling Coil Design Means . . .

Better Rectifier Operation

More Efficient Heat Transfer results from internal cooling coil. The steel coil surrounds active parts, offering more cooling surface and better heat transfer than other types. Unit maintains more uniform temperature and mercury vapor pressure.

Simplified Maintenance results from Allis-Chalmers unique unit construction. All active components are attached to the anode plate for easy withdrawal, dismantling, and re-assembling — as illustrated above.

Positive Arc Barrier is formed by the cooling coil, which is insulated from the tank. The main arc is confined within the coil, preventing arc transfer to the tank.

Years of Operation in hundreds of installations have proved the reliability, ease of operation, and simplified maintenance of Allis-Chalmers mercury arc rectifiers. You can get complete information at your nearby A-C office, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

LIVE BETTER ELECTRICALLY

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5084

Get low-cost boiler feed from oil-bearing condensate...

WITH SORBO-CEL FILTRATION

Sorbo-Cel filtration systems are compact . . . easy to operate with unskilled labor.

2¢—5¢ per 1000 gallons is all it costs you to reclaim oil-contaminated condensate with Sorbo-Cel® filtration. Sorbo-Cel can reduce oil content to less than 0.1 ppm . . . also removes rust, scale and other suspended solids. Sorbo-Cel not only saves water, but materially reduces boiler tube maintenance caused by oil and suspended solids in the feed water. And proper lubrication need not be sacrificed to insure oil-free water.

Sorbo-Cel is a diatomite powder specially processed to provide the most efficient and economical filtration of oil-contaminated water . . . for boiler feed or other process applications. It can be used with practically every type of pressure filter and requires no additional chemicals.

Free! Information and Engineering Service. Write today for your free copy of the new Sorbo-Cel brochure. If you desire, a Sorbo-Cel engineer will call for appointment to visit your plant. Address Johns-Manville, Box 60, New York 16, N.Y. In Canada, Port Credit, Ontario.

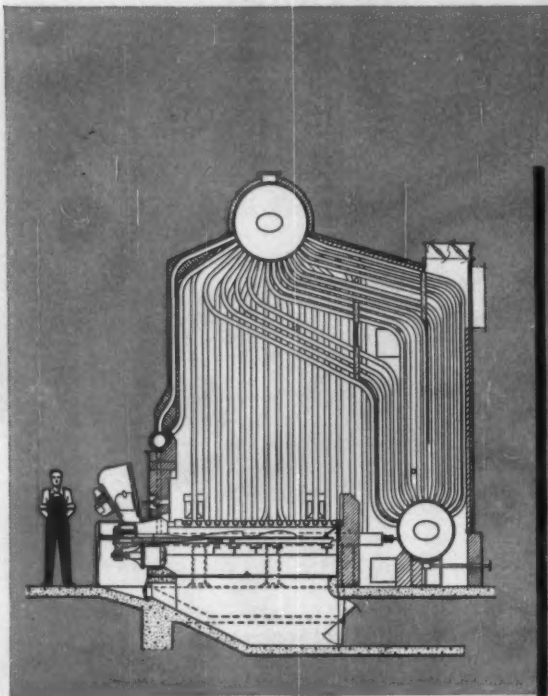
JOHNS-MANVILLE PRODUCTS

Johns-Manville SORBO-CEL®

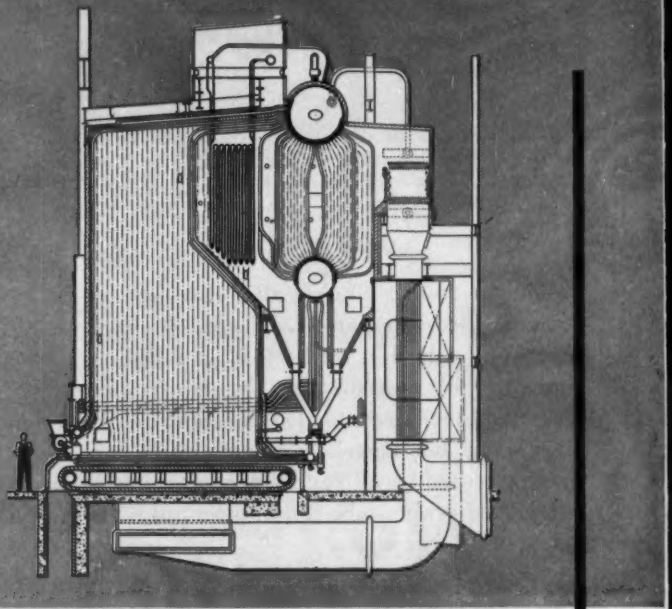
MODERN STOKER-FIRED BOILERS

Despite the relatively wide extent to which oil – and gas – have come into use for firing industrial boilers, the fact remains that coal continues to be the most economical fuel available in many areas.

Moreover many potential coal users are unaware of the tremendous improvements that have been made in recent years in the design and general effectiveness of mechanical stokers. Here at Combustion virtually the entire stoker line has had extensive design changes, all directed at improved performance. But overall performance is tied in inescapably with boiler performance. At Combustion you have the important advantage of dealing with a leading boiler manufacturer that also offers the most complete line of stokers available anywhere. You are assured, therefore, of a completely coordinated design comprising



This C-E Vertical-Unit Boiler, Type VU-10 fired by a C-E Underfeed Stoker, Type E is for a dairy. Capacity is 30,000 lb steam per hr at 150 psig. VU-10 Boilers are available for capacities from 10,000 to 60,000 lb of steam per hr. They are often equipped with C-E Spreader Stokers, dump grate type.



One of two duplicate units for a chemical company comprising C-E Vertical-Unit Boilers, Type VU-40 fired by C-E Spreader Stokers, continuous discharge type. These are baffleless boilers designed for a capacity of 150,000 lb steam per hr at 900 psig and 808 F. Coal is Eastern Bituminous.

COMBUSTION

Combustion Engineering Building, 200 Madison Avenue, New York 16, N. Y.

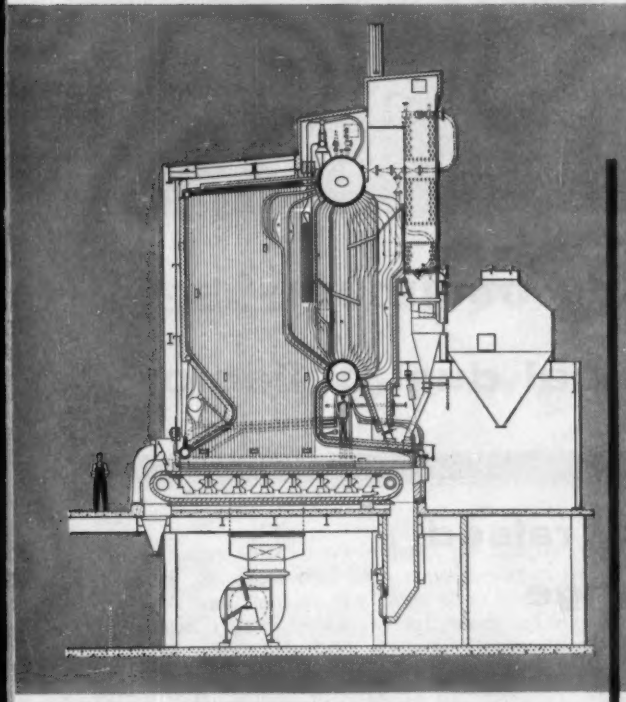
STEAM GENERATING UNITS; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS;

stoker, boiler, furnace and – if desired – heat recovery equipment and/or auxiliaries, all engineered specifically for your particular requirements.

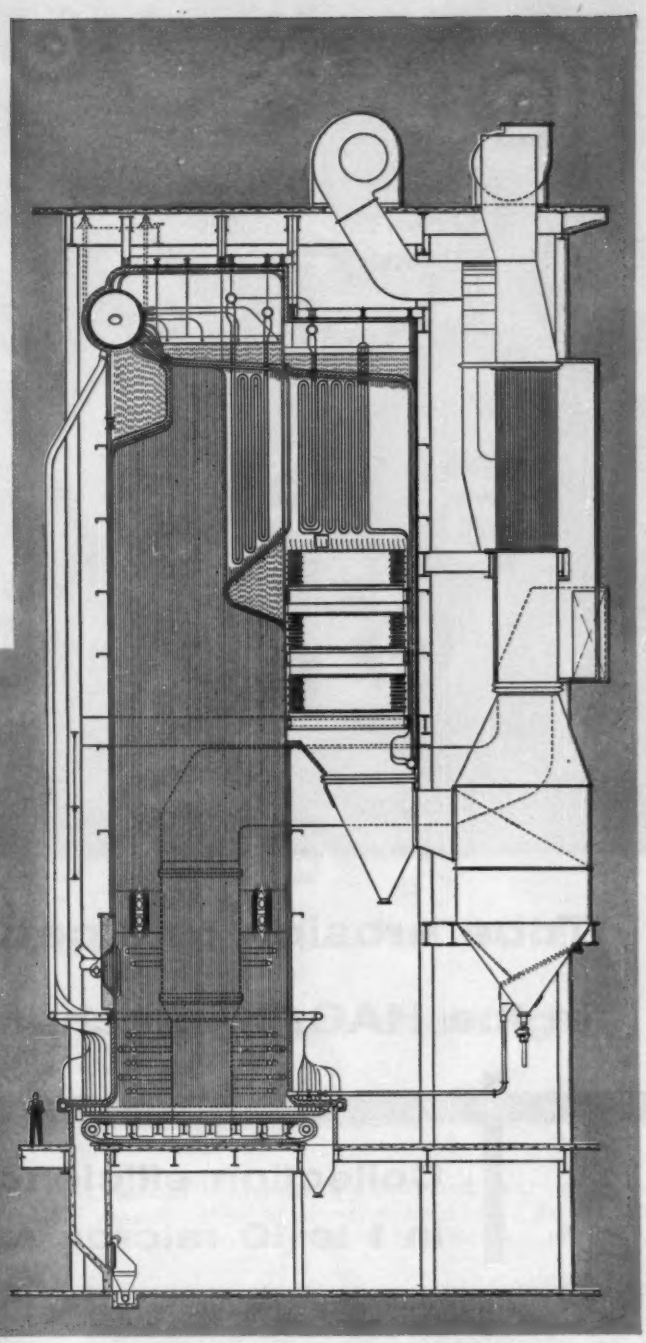
Displayed below are three – of the many – C-E stoker-fired boiler designs which, collectively, are suitable for any coal-firing conditions.

At the right is illustrated the latest – and largest – example of the C-E Bark-burning Unit, a design pioneered by Combustion and now widely used for burning bark, hogged-wood and other waste wood fuels.

So – when you are in the market for coal or other solid-fuel-burning units it will certainly be to your advantage to find out what Combustion Engineering has to offer. Our engineers will be glad to discuss your needs with you or your consultants. B-892



This C-E Unit is being installed for a soap company. It comprises a C-E Vertical-Unit Boiler, Type VU-50 fired by a C-E Traveling Grate Stoker. Coal used is Midwest Bituminous. This boiler is designed for a capacity of 100,000 lb steam per hr at 850 psig and 585 F. It is an outdoor type unit.

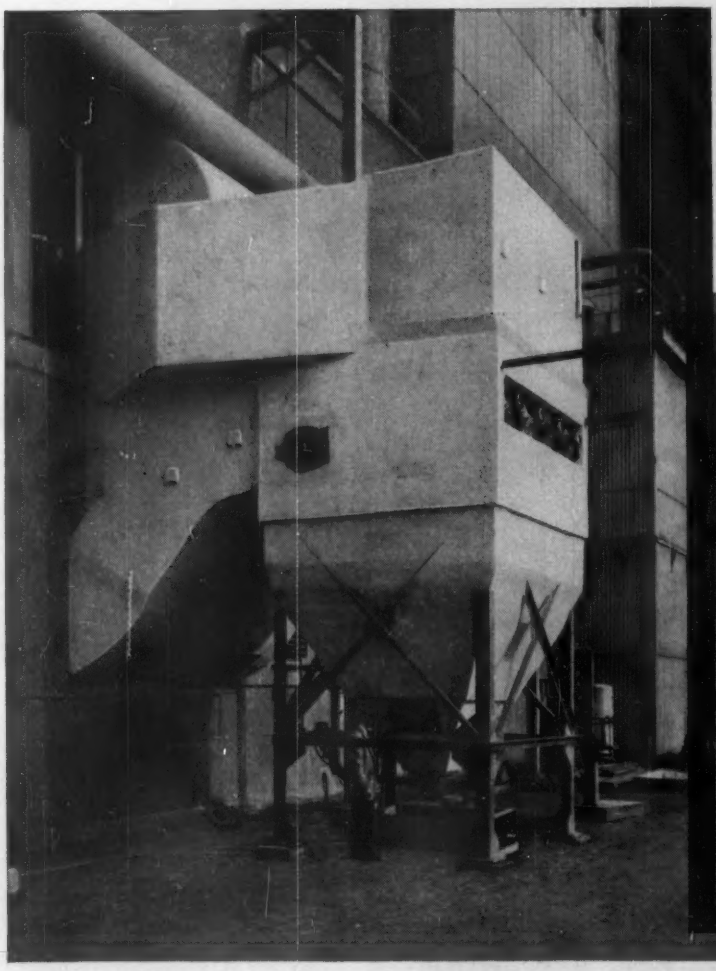


C-E Bark-Burning Unit for a paper company. This is a very large unit; capacity – 450,000 lb steam per hr, operating pressure – 1335 psig; total steam temperature – 958 F. It is designed to burn bark, natural gas, oil or any combination thereof. C-E Bark-Burning Boilers are in service for capacities as low as 20,000 lb of steam per hr.

ENGINEERING

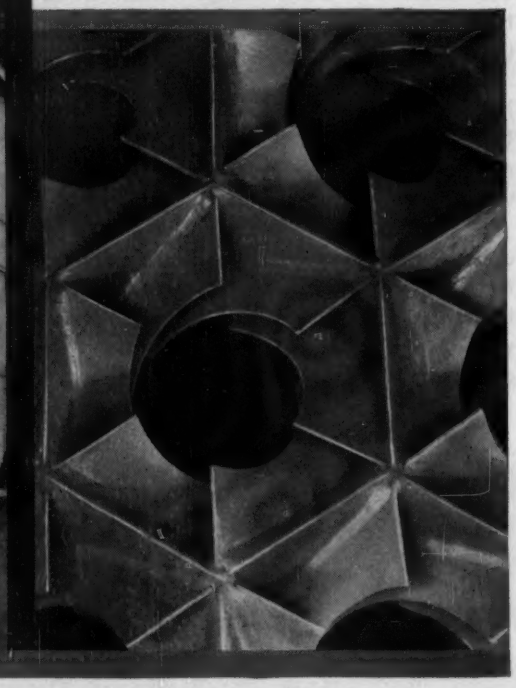
CANADA: COMBUSTION ENGINEERING-SUPERHEATER LTD.

FLASH DRYING SYSTEMS; PRESSURE VESSELS; DOMESTIC WATER HEATERS; SOIL PIPE



This installation on boilers at Pittsburgh Coke and Chemical Company has been extracting 700,000 pounds of dust a month for the past year and a half, and the collector tubes show no sign of wear. Since the installation of this collector, one more has recently been ordered.

Detail of tube assembly. Note Hexagon shape of tops—there are no flat surfaces, it is impossible for dust to accumulate.



Tube erosion reduced to minimum in the HAGAN mechanical dust collector

Collection efficiency raised in 1 to 10 micron range

The new Hagan Dust Collector extends the scope of multiple tube collectors by means of a number of unique design features. The vaned nozzle inlet discussed on the opposite page is the key to the virtual elimination of tube replacement problems, and the greatly increased efficiency of the Hagan Dust Collector. Here are some of the many cost-saving features:

Tube erosion reduced to minimum. Hagan Dust Collectors are *guaranteed* against tube failure due to erosion *for two full years.*

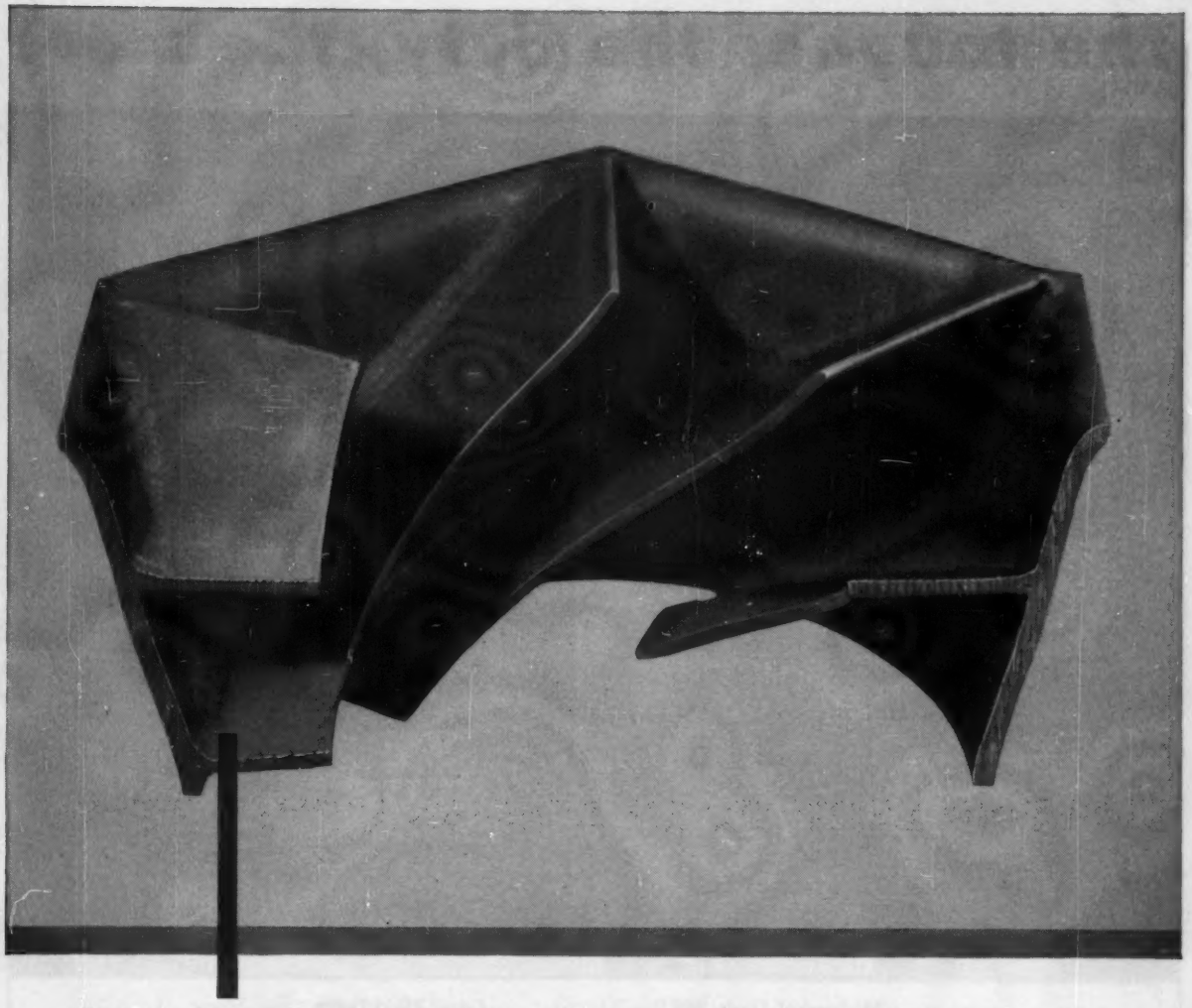
Fewer tubes—The Hagan Dust Collector employs a 6″ tube. Intensive research, employing many different tube sizes (from 2″ to 12″), established the six inch tube as yielding maximum efficiency together with greatest possible space saving.

Pressure drop 20% lower than conventional multiple tube collectors based on same efficiency.

Hexagon shaped tops—This shape permits close tube packing, eliminates dust trapping and clogging.

Easy maintenance—Ease of access to all parts makes the Hagan Dust Collector easy to inspect.

Write for Bulletin No. MSP 124-A for full description of the Hagan Dust Collector



SELECTIVE PARTICLE ACCELERATION

. . . key to prevention of erosion damage

This cutaway view shows in detail the unique shape of the inlet cell. Note that each vane is curved to follow the tube wall, and at the same time has a modified "S" shape. This curve was carefully designed to produce a smooth, even deflection of the air stream. The space between the vanes narrows from top to bottom, providing a controlled increase in air velocity. Result: Selective Particle Acceleration.

Smaller, lighter dust particles accelerate more readily, and spiral into the collector tube with a high initial velocity. The larger particles accelerate more slowly reaching a velocity sufficient for separation, but not enough to cause erosion. Both large and small particles are removed efficiently from the air stream.

This principle of Selective Particle Acceleration is an exclusive Hagan development, and has several specific advantages:

Long collector life, low erosion loss permits *two year guarantee* against erosion damage.

Collection efficiencies are increased, particularly in the less than 10 micron particle sizes, the area in which many conventional collectors *lose* efficiency.

Efficiencies maintained despite varying operating load conditions. The Hagan Dust Collector's effectiveness remains high even at 50% of rated capacity.

HAGAN CORPORATION

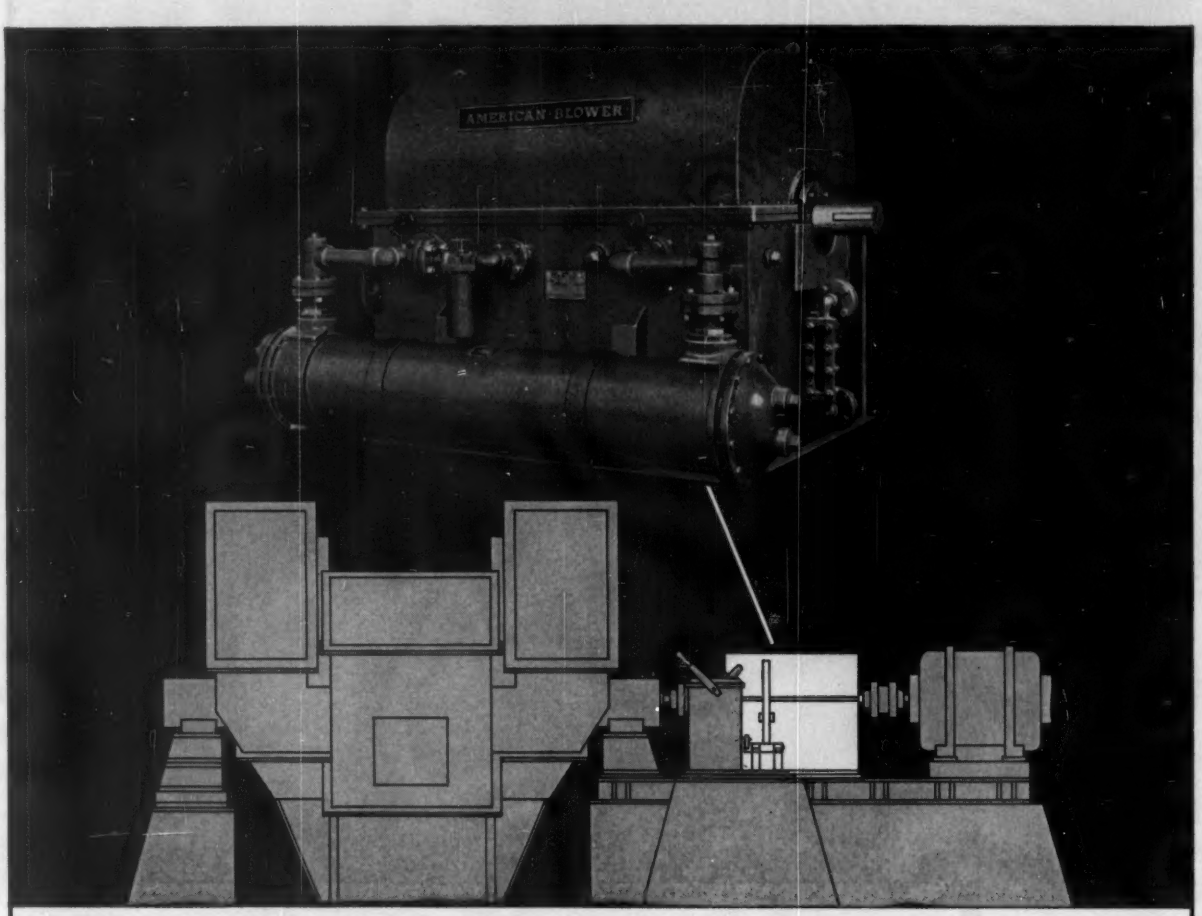
HAGAN BUILDING, PITTSBURGH 30, PA.

HAGAN

Systems and Components for: Boiler Combustion Control, Metallurgical Furnace Control, Process Control, Aeronautical Testing Facilities • Industrial Water Treatment • Chemicals for Water Conditioning

HAGAN SUBSIDIARIES: CALGON, INC. • HALL LABORATORIES, INC.

The tougher the duty, the more

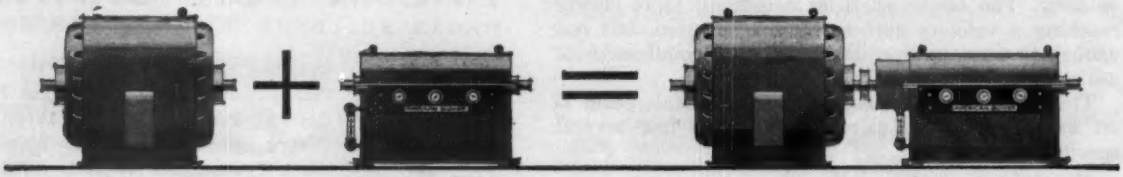


Mechanical Draft Fan Gýrol Fluid Drive Motor

LARGER MECHANICAL DRAFT FANS — Gýrol Fluid Drive gives you the kind of accurate, efficient control of mechanical draft that results in important power savings, longer equipment life. The reason: Fluid Drive's infinitely adjustable speed control, which enables each fan to operate at its optimum design or selection point.

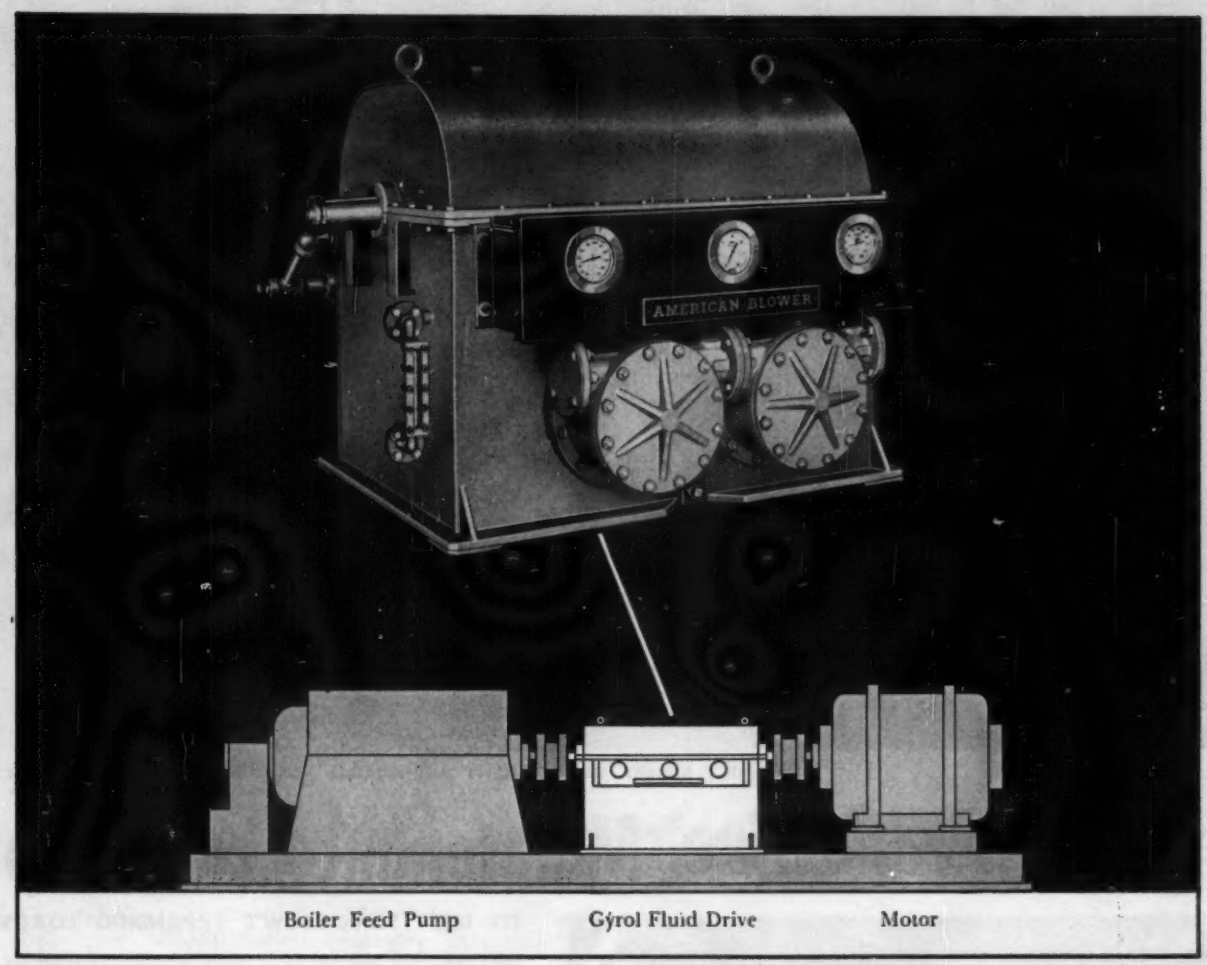
This adjustable-speed feature saves horsepower, gives good, stable volume and pressure control over the operating range . . . simplifies motor-starting equipment . . . reduces damaging high- and long-duration inrush currents on the motors . . . provides no-load starting of high WR^2s that exist in the new, high-volume, high-pressure fan wheels.

What's more, it prolongs life of fan bearings; reduces fly-ash abrasion on fan wheel, fan scroll, inlet boxes, and breeching connections. When you add to these advantages the reduction in noise level, it becomes increasingly clear that the tougher the duty, the more you need Gýrol Fluid Drive for control of mechanical draft.



Rugged constant-speed induction motor American Blower Gýrol Fluid Drive Smooth, adjustable-speed control

you need Gýrol® Fluid Drive



Boiler Feed Pump Gýrol Fluid Drive Motor

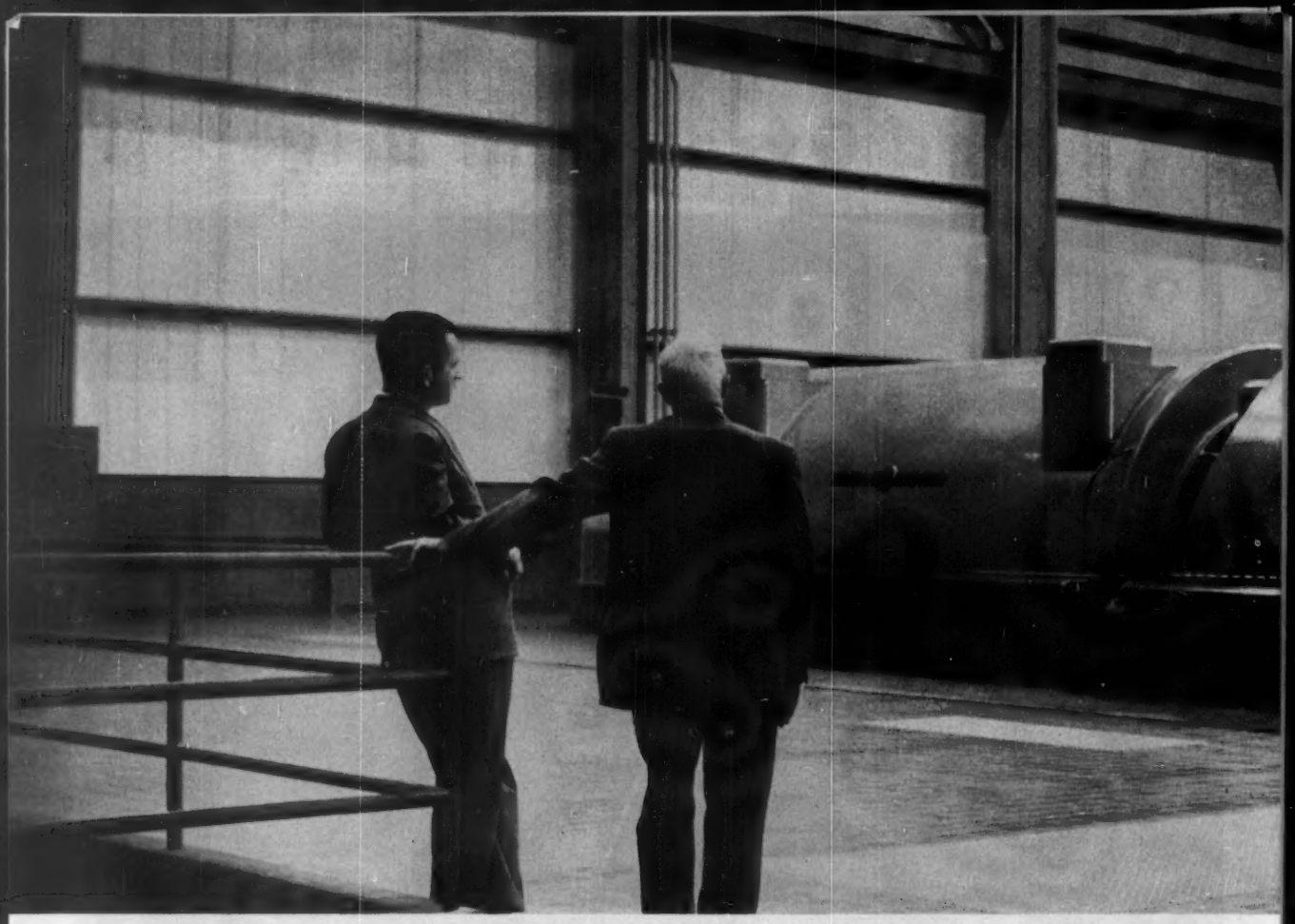
LARGER BOILER FEED PUMPS — As larger boiler feed pumps are built, there is a greater need for higher efficiencies and more accurate control. That's why more and more consulting and utility engineers are recommending Gýrol Fluid Drive.

You see, Gýrol Fluid Drive offers adjustable-speed pump control that saves power over the entire operating range by eliminating wasteful throttling. Then, too, Fluid Drive reduces wear on bearings and other vital parts by operating the pump at speeds that fit boiler demands. Paralleling of pumps is simplified. And emergency changeover from operating to standby pump is fast and foolproof—there's no need for boiler shutdown.

If your plant expansion calls for boiler feed pump control, it will pay you to talk to an American Blower engineer. He can show you where Gýrol Fluid Drive can save power, cut costs, give you a more efficient operation. Contact our nearest branch office, or write us direct. American Blower Corporation, Detroit 32, Michigan. In Canada: Canadian Sirocco Company, Ltd., Windsor, Ontario.

AMERICAN BLOWER

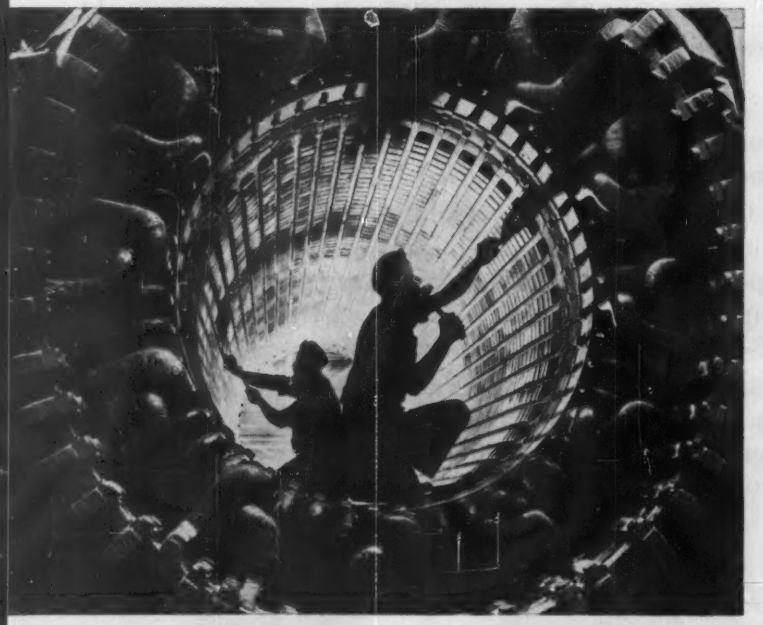
Division of American-Standard



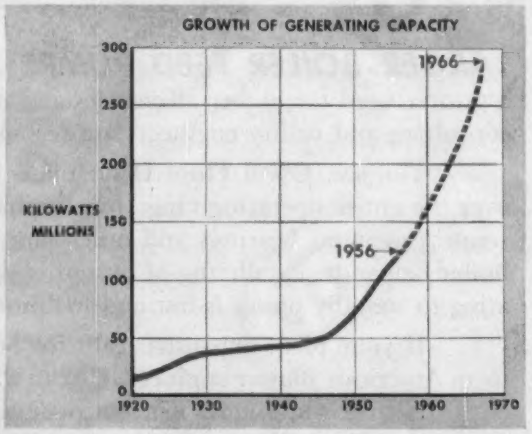
CAREFUL PLANNING FOR PRODUCTIVE MAINTENANCE INCLUDING STOCKING SPARE PARTS

How *Productive* Maintenance can help

TO MEET TOMORROW'S EXPANDING LOADS



THE FACILITIES of the world's finest turbine plant and 46 service shops located throughout the country back your General Electric unit.



G.E. works with electric utilities and consulting engineers in these vital turbine-generator areas:

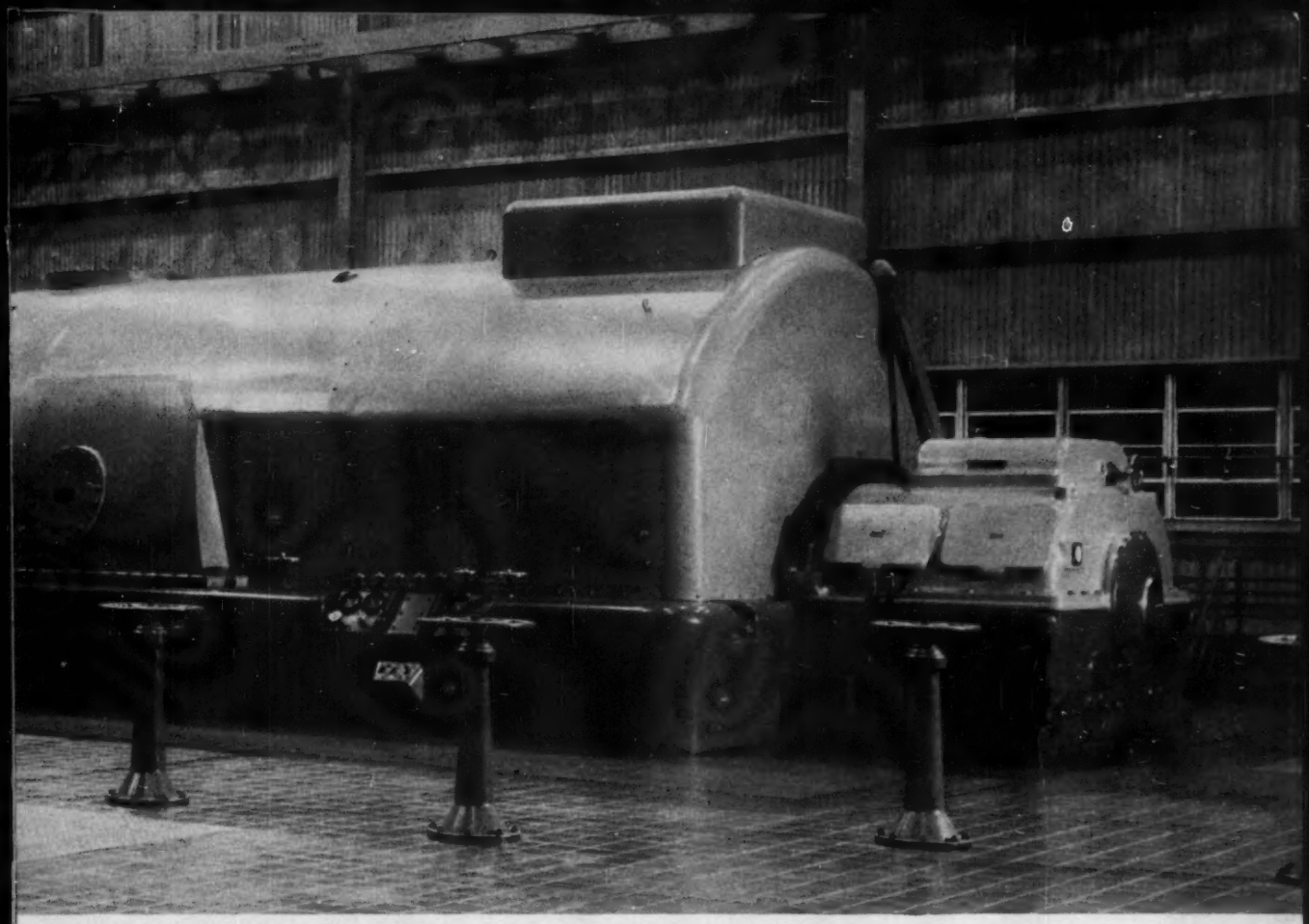
BASIC RESEARCH

APPLIED RESEARCH

PRODUCT DEVELOPMENT

TESTING

MAINTENANCE: PRODUCTIVE MAINTENANCE



AND REVIEWING SCHEDULED OVERHAULS CAN REDUCE TURBINE-GENERATOR DOWNTIME.

keep a turbine-generator on-the-line

General Electric's *Productive* Maintenance plan can help you reduce turbine-generator maintenance expenses. Here's how:

1) Maintaining a supply of General Electric spare parts can save valuable time. These parts fall into three categories:

a) Recommended parts such as thrust rings, springs for packing seals, brushes and brush holders, gaskets for control mechanisms, studs and nuts;

b) Optional spares such as rings for packing seals, bushings for control mechanisms, bearings and sealing rings for oil pumps; and

c) Major parts such as main bearings, rotors and stator bars.

G.E. can help you decide which to carry.

2) By using General Electric renewal parts and inspection service you get complete and accurate information about construction and engineering characteristics for your G-E unit. This means fast service and thorough engineering. General Electric is familiar with your machine and at the time of planning overhauls can suggest possible modernization.

3) With the trend toward more uniform loads throughout the year—both summer and winter—scheduling outages is becoming a real problem. Your General Electric turbine-generator representative can help you plan your overhaul schedule. By applying G.E.'s *Productive* Maintenance plan, and where operating conditions warrant, it may be possible to extend the time between overhaul periods.

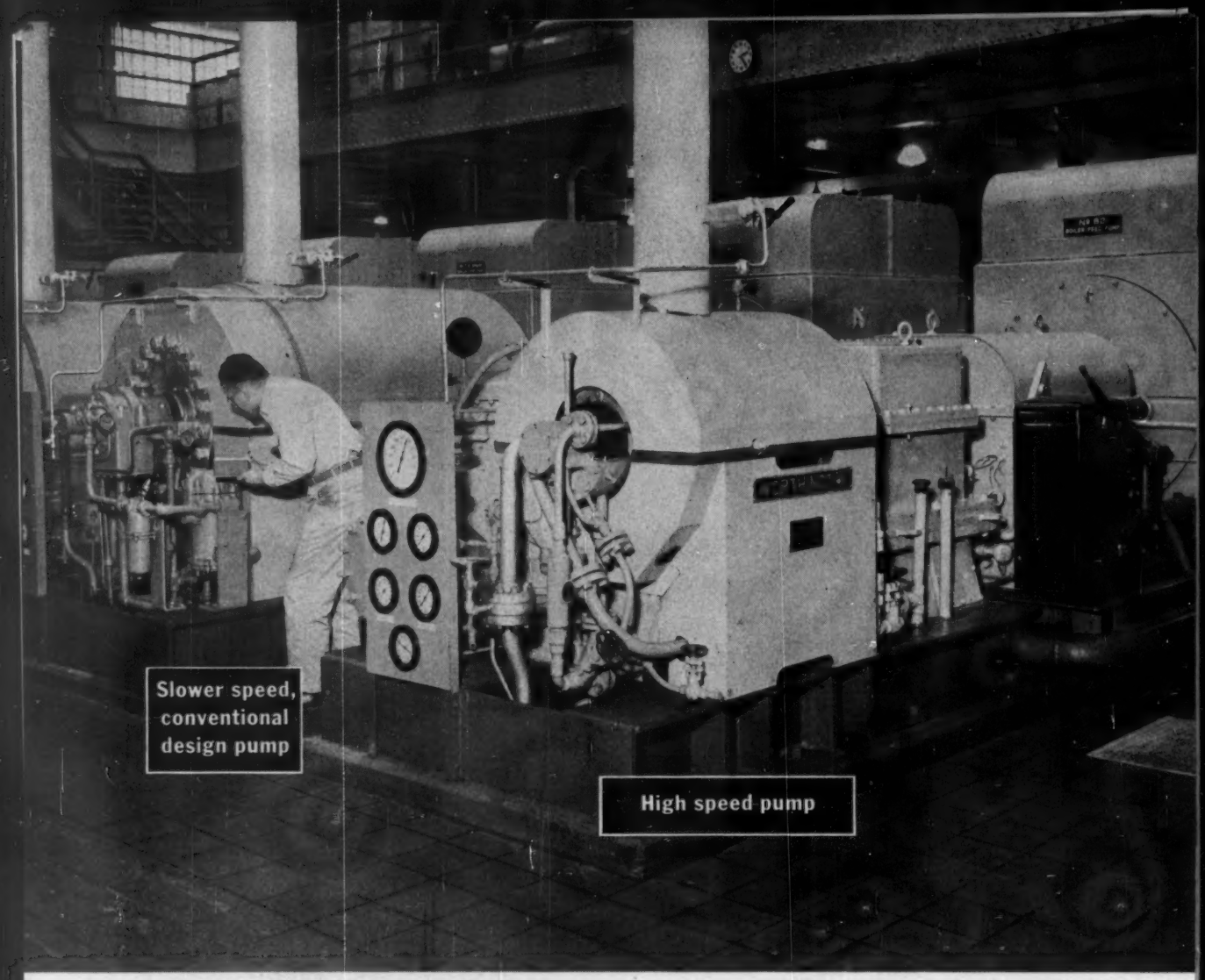
You can get service 24 hours a day, seven days a week if necessary on your General Electric unit. The world's most modern turbine-generator manufacturing facilities and 46 G-E service shops are ready to help you.

Planning *Productive* Maintenance is just one of many areas in which General Electric is co-operating with electric utilities to prepare for tomorrow's load growth today. For more information write for bulletin GEA-6087. Large Steam Turbine-Generator Department, General Electric Company, Schenectady 5, New York.

254-46

Progress Is Our Most Important Product

GENERAL ELECTRIC



6,000..8,000..10,000 rpm?

How much speed for modern boiler feed pumps?

With the trend towards superpressure power plants, a new look is being taken at existing boiler feed pump designs.

It's apparent that pressures as high as 5,000 psi cannot be reached economically at conventional speeds of 3,600 rpm without sacrificing reliability.

The 9,000 rpm Worthington pump above breaks through the speed barrier. Alongside a conventional unit with duplicate pressure and capacity ratings, its smaller size is dramatically evident. And this means greater reliability, lower costs. In operation since 1954, it has given satisfactory and reliable service in the new Kearny Generating Station of Public Service Electric and Gas Company, Kearny, N. J.

Twenty-two more Worthington high speed pumps on order. Speeds range from 6,500 to 9,000 rpm. If necessary, Worthington sees no reason why operating speeds shouldn't go even higher, without departing from experience-proved construction principles.

For more information, get in touch with your nearest Worthington District Office. If you'd like a copy of Bulletin RP-703, an interesting discussion of "High Speed Feed Pumps For Superpressures," write to Section C65, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont. C-6.5

WORTHINGTON

STAINLESS STEEL*

TO MARK PROGRESS

FITTINGS 1/8" THROUGH 36"

LADISH

...FOR COMPLETE SERVICE IN *Controlled Quality* FITTINGS

When you need service in stainless and alloy fittings... regardless of material specification, size, type, or wall thickness... you can depend on the Ladish Controlled Quality line and the services of your Ladish Stainless Distributor for complete satisfaction.

IPS WELDING FITTINGS		½" through 36" From Sch. 5S to wall thicknesses through 4"
O.D. TUBING FITTINGS		1" through 36" From .049" wall to .250" wall
MSS AND ASA FLANGES		1" through 24" 150 lb. through 2500 lb.
150 LB. SCREWED FITTINGS		⅛" through 4"
FORGED SCREWED AND SOCKET FITTINGS, UNIONS		⅛" through 4" 2000 lb. through 6000 lb.

THE COMPLETE *Controlled Quality* FITTINGS LINE

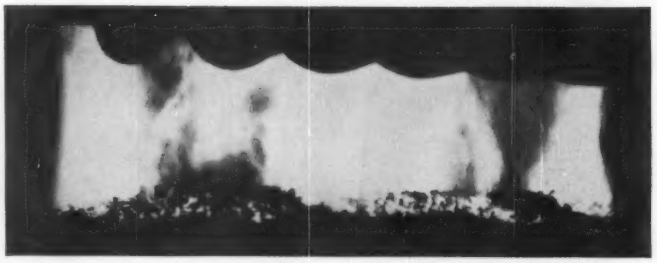
LADISH CO.

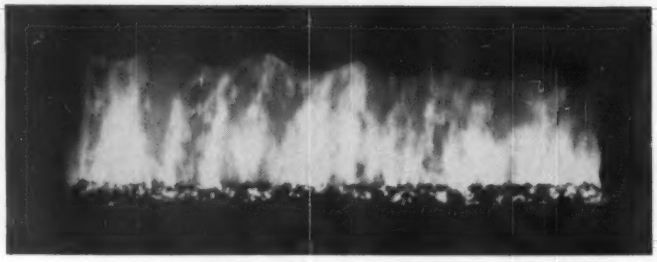
CUDAHY, WISCONSIN
MILWAUKEE SUBURB

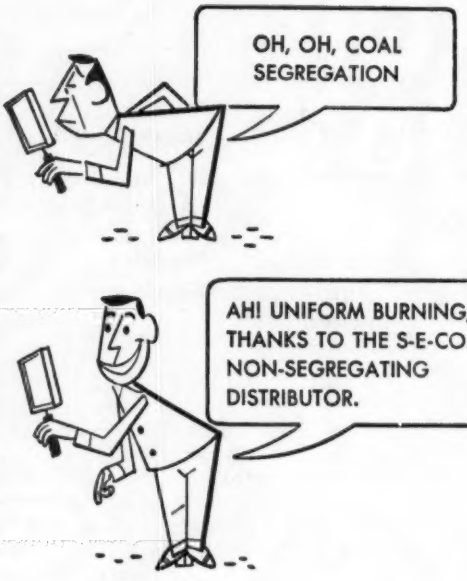
District Offices: New York • Buffalo • Pittsburgh • Philadelphia • Cleveland
Chicago • St. Paul • St. Louis • Atlanta • Houston • Odessa • Tulsa • Denver
Los Angeles • San Francisco • Seattle • Havana • Mexico City • Brantford, Ont.

*Also furnished in any forgeable material specification including...
Titanium, Aluminum, Copper, Nickel, and Chromium Base Alloys.

Look at the fire on your stoker



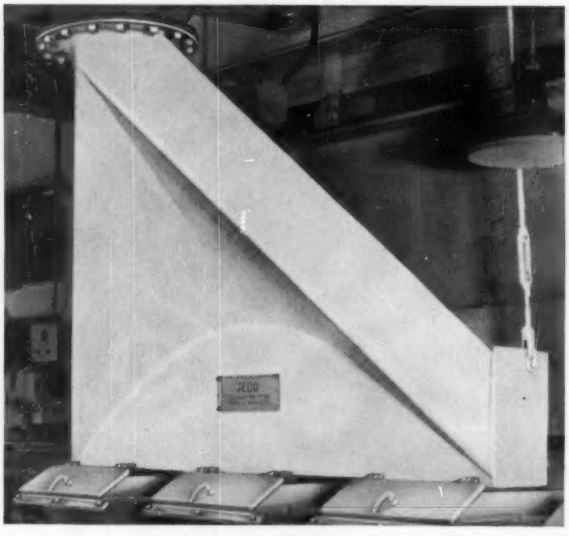




• Coal segregation on your stoker means increased costs due to uneven combustion. Fine coal zones present greater resistance to air flow. Insufficient air means incomplete combustion, unburned fuel in the ash pit. In addition, these zones produce more than the customary amount of smoke.

Coarse coal zones, on the other hand, present less resistance to air flow. More air than required means low CO_2. Also, uncovered stoker iron is exposed to high furnace temperature. Result — expensive repairs and down time.

Take another look at your stoker fire. If you see the tell-tale signs of segregation, you need a S-E-Co. CONICAL Non-Segregating Coal Distributor. This distributor has effectively eliminated coal segregation in hundreds of plants throughout the country. For more information on how you can increase the efficiency and economy of your stoker, write for our Bulletin No. 73. Remember, in scales, valves or distributors, you get more value when you buy S-E-Co.



A graphic description of the principle of the S-E-Co. CONICAL Non-Segregating Distributor (pictured above) is found in our Bulletin No. 73. Write now for your copy.

SPECIALISTS IN
BUNKER TO PULVERIZER AND
BUNKER TO STOKER EQUIPMENT

STOCK Equipment Company

745-P HANNA BLDG., CLEVELAND 15, OHIO

Hall Industrial Water Report

VOLUME 4 APRIL 1956 NUMBER 2

Corrosion—a Plague on All Our Houses

—presents problems as varied as industry, for all industry uses water in some way and all water causes corrosion to some extent. Thirty years of experience in thousands of individual plants enables Hall Laboratories to apply to current problems the most practical techniques for control of corrosion, many of them developed by Hall research and engineering.

Condensate System Saved

On his first visit to a new client, a hospital in Virginia, Hall engineer C. F. Raines encountered corrosion of the black iron condensate system so "terrible" that two men were kept constantly busy just replacing fittings and piping.

Both pitting and etching of the steel were occurring, suggesting that both dissolved oxygen and carbon dioxide were factors in the corrosion. However, the oxygen was not readily accounted for.

Raines examined the feedwater heater and found there was no way for the steam from the deaerating section to pass to the vent condenser. A tee had been installed in the line to take care of this, but instead had been used for a condensate line from the laundry. By proper rearrangement of connections, adequate venting was obtained as had originally been intended.

Additional changes included feeding 1 ppm. of Hagafilm® to the boilers to inhibit return line corrosion, and Santosite to react with residual oxygen not removed in the feedwater heater. Condensate line corrosion became negligible. Instead of replacing the entire condensate system at a cost of several thousand dollars, the plant now protects the system chemically at a cost of 17 cents a day.

Gasket "Corrosion" Problem Quickly Solved

Attack of boiler handhole gaskets at the pressure points of the locking clamps—center top and center bottom—on the sealing surfaces was experienced at a plant in West Virginia serviced by Hall engineer Wm. J. Reese.

At first it was thought that a highly-concentrated solution of caustic had dissolved the asbestos packing.

This possibility was rejected when it was concluded, after careful examination, that the gaskets had been distorted due to excessive pressure applied to the extremities of the minor axis in order to prevent leakage at the ends of the major axes. Subsequent investigation revealed the machined surfaces of the seats did not overlap properly at the ends of the minor axes, and the high points coincided with the areas of attack on the damaged gaskets. Refinishing the gasket seats eliminated the problem.

Bacterial Growths Get the Air

Severe corrosion under rusty deposits in an ammonia condenser prompted a food processing plant in Ohio to call on Hall Laboratories for help. Suspecting iron-fixing bacteria to be responsible for the hydrous ferric oxide deposits, Sales Engineer J. M. Harvey sent samples of water and a sample of wet deposit to Pittsburgh for investigation.

Bacteriological examination showed both iron-fixing and sulphur bacteria in the well water. Chemical examination showed the water to be high in bicarbonate hardness, with approximately 2 ppm. of iron and manganese in solution. Chlorination of the water was needed to kill the living organisms, but this would oxidize the iron and manganese and cause them to deposit, even though the iron-fixing bacteria which had been causing this were eliminated. Harvey met this dilemma by recommending stabilization of the calcium carbonate, iron, and manganese by continuous feed of threshold amounts of Calgon directly to the bottom of the well, followed by intermittent addition of hypochlorite to the discharge side of the well pump.

But this plant had everything. Now a different problem developed with an accumulation of slime in the condensers. In a new sample of wet deposit, Hall Laboratories found sulfate-reducing bacteria. Since these peculiar "bugs" thrive only in the absence of oxygen, continuous aeration of the well water was recommended to supplement the intermittent chlorination.

Operating experience has proved that aeration has been decidedly beneficial. There have been no condenser outages for cleaning, whereas formerly cleaning was necessary several times each summer.

These Whistles a Bargain, Sir!

In a Michigan plant the original soot blowing system lacked the whistles normally installed. When the steam valve was shut off after soot blowing, the vacuum produced drew gases from the ash pit through the drain into the piping. Severe corrosion resulted. Correction involved installation of the whistles to prevent vacuum by acting as vents.

Ben Franklin's advice to consider alternatives before buying a whistle lest disappointment prove payment too dear for the choice could thus be answered, "*These* whistles were a bargain, Mr. Franklin."

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information write, wire or call Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pa.

Water is your industry's most important raw material. Use it wisely.

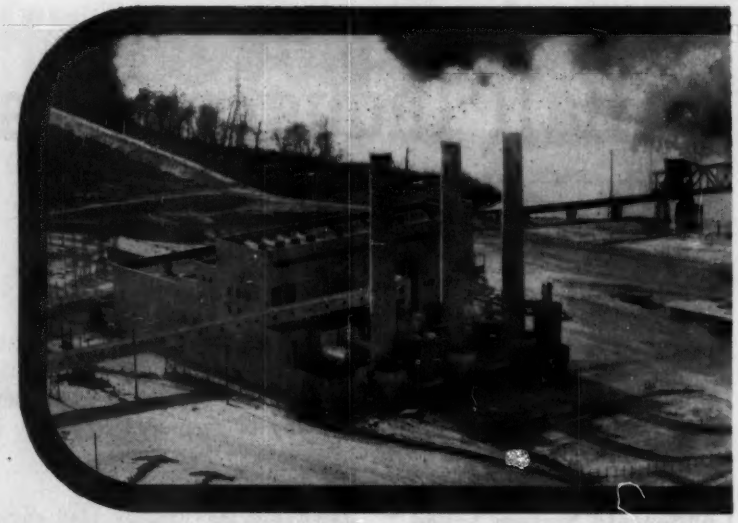
Hall Laboratories, Inc.—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water

South Carolina Generating Company's

(Wholly-owned Subsidiary of South Carolina Electric & Gas Co.)

URQUHART STATION

UNIT No. 3



where . . . **REPUBLIC** *Automatic*

COMBUSTION CONTROLS *Anticipate* **FUEL-AIR-WATER REQUIREMENTS!**

BRIEFLY—this is how it works:

Controls Respond First to Load Changes

REPUBLIC "Electronic Master" combustion control first detects any change in steam flow and immediately transmits a signal proportional to that change to the combustion air, coal pulverizers and/or gas valve, and feedwater valve.

Curb Pressure-Water-Temperature Changes

Corrective settings of each of these controls starts *with* the steam flow change and follows the change closely; this keeps steam, fuel, air, water and (of course) flue gas flows in the closest possible balance, minimizing fluctuations of header pressure, drum water level, and superheater outlet temperature.

Pressure Controls Follow Up

Any slight change of header pressure or drum level that *does* occur is immediately detected and fed to the proper control as a modulating signal that restores complete balance . . . quickly.

Combined Fuels—Stable Operation

This combination of flow-initiated and follow-up adjustments, with electronic control and pneumatic drive units, means top-notch stability, accuracy, sensitivity and reliability for Urquhart Station's Unit No. 3, even while burning combined fuels!

REPUBLIC FLOW METERS CO.

URQUHART STATION, UNIT No. 3
STEAM DATA:
Rated Capacity 700,000 LB/HR ——— 1825 PSI
SUPERHEAT 1010 F —— REHEAT 1010 F
FUEL: PULVERIZED COAL AND/OR GAS
COMBUSTION CONTROL:
REPUBLIC Automatic ELECTRONIC

Urquhart No. 3's control room where automatic and remote-manual controls are centralized.

Planned expansion of power for the great Southeastern United States is typified by the latest addition to Urquhart Station of the South Carolina Generating Co. Planned by Gilbert Associates, Unit No. 3 is modern today and will be modern tomorrow —*and will be considered "modern" by performance as well as appearance standards.*

REPUBLIC's "Electronic Master" combustion control is a logical partner in such advanced thinking. The quick, long arm of electronic control plus reliable, powerful actuation by pneumatics gives Urquhart No. 3 the reflexes it needs to meet any operating crisis and hold single—or combined—fuel consumption low. For greatest speed of control, REPUBLIC has provided a load-responsive system that regulates all combustion factors *before* pressure drops or jumps occur. Any pressure fluctuations following this advance adjustment are very limited and are promptly compensated by a pressure control system that modulates the fuel and air control signals.

REPUBLIC's three element feedwater regulator adjusts feedwater flow in proportion to steam flow, and follows up this action with a correction for drum level. Total level fluctuations are thereby held to a strict minimum.

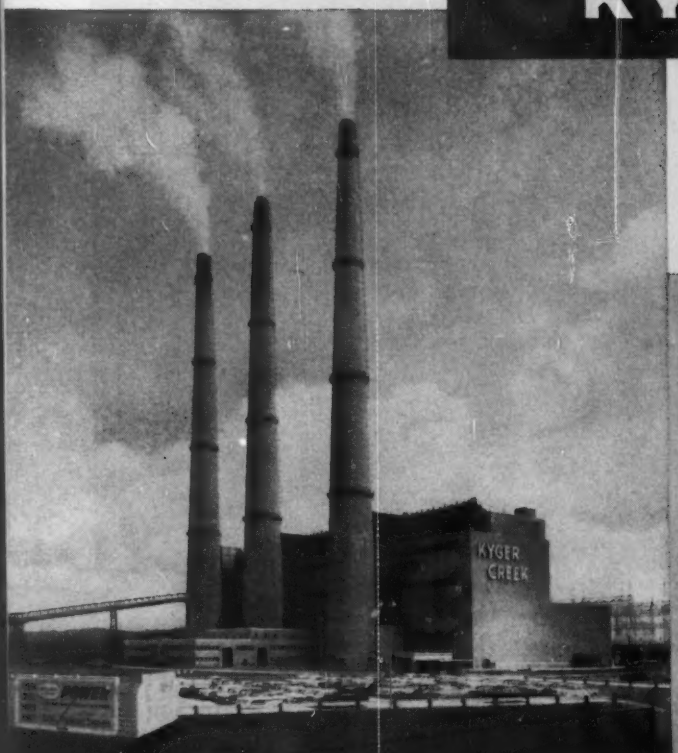
Remote manual operation of any or all control units is possible at any time. The operator need only throw the transfer switch on his panel and take over; indicators at the operating station show electronic loadings to the regulators and positioners, and show the rate of response and position. All electronic amplifiers have built-in surplus capacity for extra life and special design features for quick maintenance when needed.

This comprehensive treatment of control problems is typical of REPUBLIC engineering. Equally thorough follow-up and servicing make REPUBLIC a helpful partner in new or modernized power operations—of any size.

Need Help With "Early Stage" Planning?
If you are planning ahead for new conventional or "unconventional" facilities, remember that REPUBLIC, too, is planning ahead. For help in projecting your new facilities in terms of new control, metering and recording equipment—and the latest in top quality valves—contact REPUBLIC's Engineering Department as soon as this help can be beneficial.

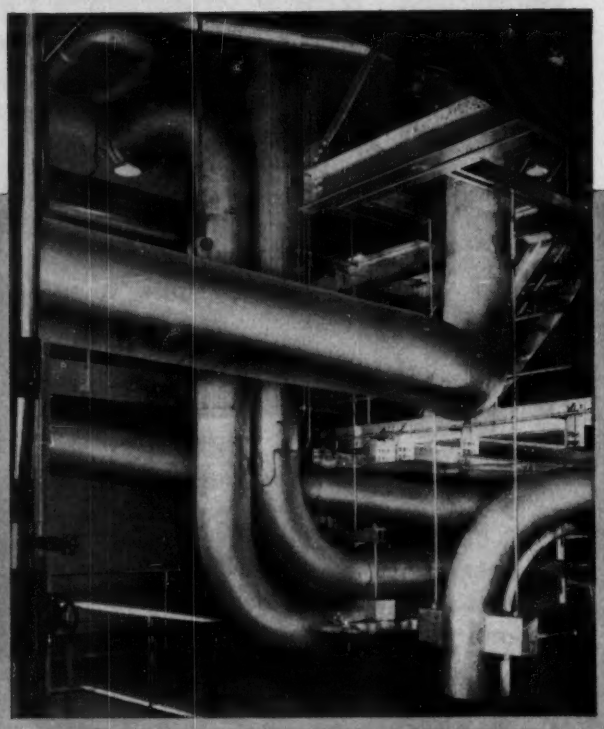
2240 Diversey Pkwy., Chicago 47, Illinois

KYGER CREEK . .

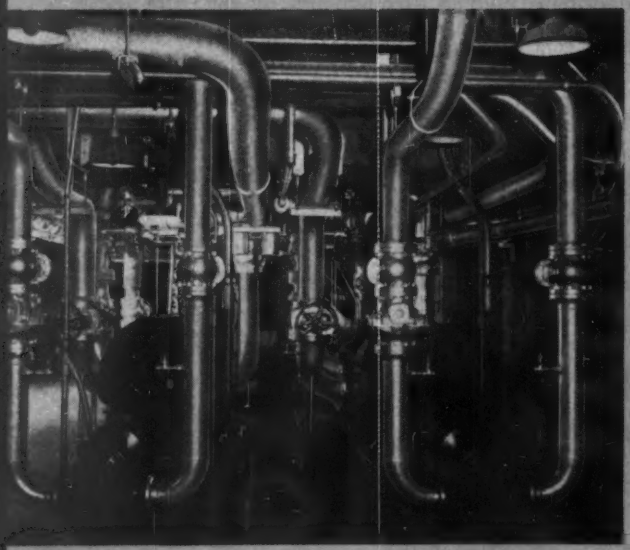


COMPLETED APPROXIMATELY THREE MONTHS AHEAD OF THE ORIGINAL FAST SCHEDULE

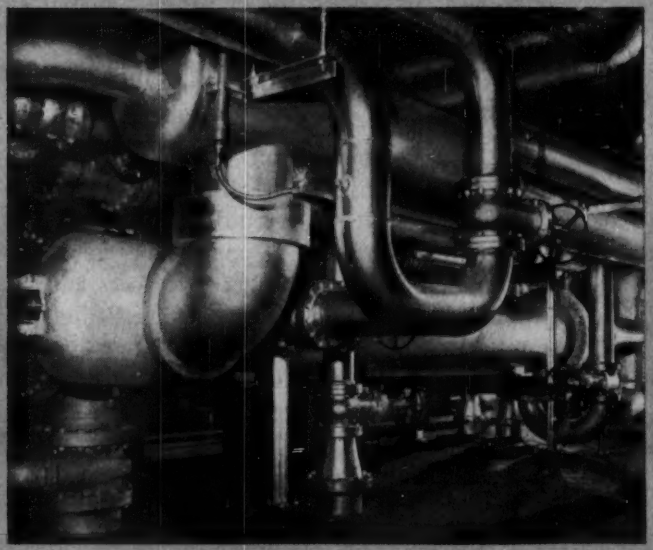
Operating Conditions: 2070 psi and 1050° F.



Main steam piping is 13" OD, 2¼" wall thickness, 2¼% Cr—1% Mo.
More than 1,300 high pressure welds were made in the field; inspection by Gamma Ray disclosed that only three of these welds needed minor repair.



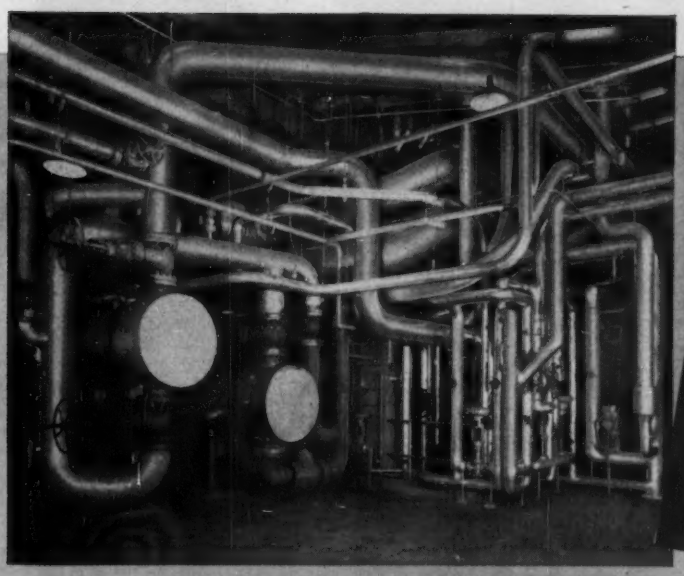
Condensate piping.
The piping for Kyger Creek required approximately 3,500 valves larger than 2", 16,000 valves 2" and smaller, and 6,000 instrument valves.



Condensate and bearing cooling water coolers.
Kyger Creek piping used approximately 62,000 carbon steel machine bolts, 5,800 alloy studs, 7,000 carbon steel backing rings and 2,000 alloy backing rings.

MIDWEST . . . PIPING FABRICATORS AND

. largest power plant piping job ever done by one contractor . . .



Heaters and auxiliary steam station.
Of the approximately 11,740 pieces of shop-fabricated piping supplied by Midwest in record time, less than ¼ of 1% (24 pieces) required correction for all causes.

. . . and that contractor was MIDWEST PIPING CO.

With a capacity of 1,075,000 kilowatts, Kyger Creek Plant of the Ohio Valley Electric Corporation† is the largest power plant piping contract (combining fabrication and erection) ever performed by a single contractor. Midwest Piping Company was selected for this critical project because of its long experience in serving the public utilities and because of its outstanding shop facilities and field organization. That this confidence was not misplaced is evidenced by the fact the piping was finished ahead of the original fast schedule.

Unit No. 1 was placed in service during January, 1955 while the fifth unit went on stream less than a year later . . . in December, 1955.

Some idea of the size of this project can be gained from the fact that Midwest supplied approximately 11,740 subassemblies of shop-fabricated piping and at one time had more than 650 men on the erection. To meet the required delivery schedule, fabrication was done at both the St. Louis and Clifton Plants.

Whether for a small job or a giant . . . Midwest can furnish you better piping faster. You will find it to your advantage to call in Midwest whenever you need piping.

OVEC†
THE SPONSOR COMPANIES

Appalachian Electric Power Company*
The Cincinnati Gas & Electric Company
Columbus and Southern Ohio Electric Company
The Dayton Power and Light Company
Indiana & Michigan Electric Company*
Kentucky Utilities Company
Louisville Gas and Electric Company
Monongahela Power Company**
Ohio Edison Company
Ohio Power Company*
Pennsylvania Power Company***
The Potomac Edison Company**
Southern Indiana Gas and Electric Company
The Toledo Edison Company
West Penn Power Company**

SUBSIDIARY OF: *American Gas and Electric Company **The West Penn Electric Company ***Ohio Edison Company

Engineering by American Gas and Electric Service Corp. and Sargent & Lundy.

MIDWEST PIPING COMPANY, INC.

Main Office: 1450 South Second St., St. Louis 4, Mo.
PLANTS: ST. LOUIS, CLIFTON, N. J. and LOS ANGELES

SALES OFFICES: NEW YORK 7—50 CHURCH ST.•LOS ANGELES 33—520 ANDERSON ST.•BOSTON 27—426 FIRST ST.
CHICAGO 3—79 WEST MONROE ST.•SAN FRANCISCO 11—420 MARKET ST.•TULSA 3—224 WRIGHT BLDG.
HOUSTON 2—1213 CAPITOL AVE.•CLEVELAND 14—616 ST. CLAIR AVE.•MIAMI 34—2103 LE JEUNE RD.
ONEIDA, N.Y.

MIDWEST PIPING SERVICE IS NATIONWIDE

7576

CONTRACTORS FOR MORE THAN 50 YEARS

"BUFFALO" TYPE "CR" RADIAL BLADE FAN

VENTILATING | AIR CLEANING | AIR TEMPERING | INDUCED DRAFT

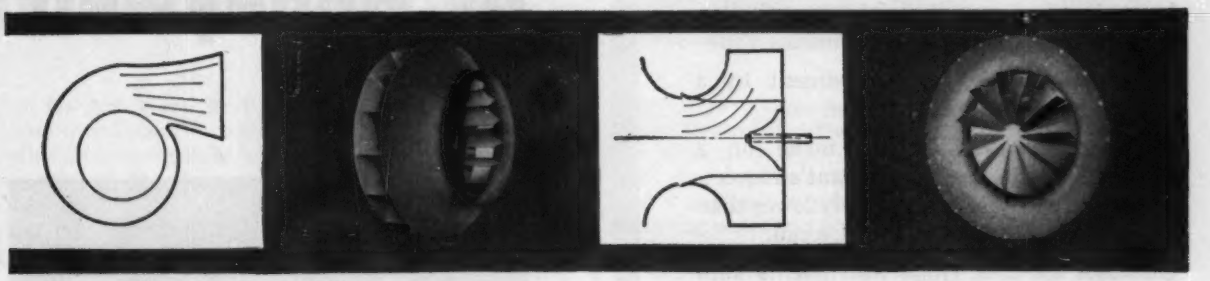
Engineered for high volume-high pressure service

Already proving its overall economy in stoker-fired induced draft, cement plant and other heavy-duty industrial service, this newest "Buffalo" Fan has the following advantages:

- **HIGH** Mechanical Efficiency — above 78% over a wide range.
- **DESIGNED** for high dust loading conditions.
- **LOWER** First Cost, when its high pressure, high capacity characteristics mean a smaller fan for the job.

Ilustrated here are the features that contribute to this desirable balance of efficiency and resistance to abrasion — the streamlined housing with diverging outlet — the new radial wheel with its deep, smoothly curved inlet flange mating with the inlet bell to form a true half-circle entry into the wheel. The wheel blades are radial at the tip, curving smoothly forward at the inlet. Further, "Buffalo" CR Fans are designed for use with an open inlet or with the highly efficient "Buffalo" variable inlet vanes shown.

WRITE FOR BULLETIN FD 205 and check the "Q" Factor* features that will give you the greatest all-around satisfaction and economy with this quality fan.



STREAMLINED HOUSING and diverging outlet aid efficiency, reduce abrasive effect.

TYPE "CR" RADIAL WHEEL — note how mating flanges of inlet bell and wheel flange form a true half-circle entry path with no flat sections or irregularities.

ACCURATE VOLUME CONTROL without reducing fan performance is obtained with "Buffalo" cantilevered variable inlet vanes set well into inlet bell throat.

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY

BUFFALO, NEW YORK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo"

EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Frequent Instrument Check-ups Prevent Emergencies

The economical way to protect your investment in instrumentation is a Honeywell Periodic Service Plan. Under this plan, a Honeywell service specialist comes to your plant at regular intervals to—

— Check your Brown instruments and calibrate them against accurate laboratory standards.

— Inspect all moving parts, clean and lubricate them, and replace where necessary.

You get this kind of service performed regularly for your office equipment such as typewriters and calculating machines . . . for your automobile . . . and even for yourself by periodic check-ups by your doctor. You've learned that the ounce of prevention is a good investment. Well, the same philosophy applies to instruments, too. Keeping them in good condition is far more economical than waiting for emergencies to throw production schedules into a tailspin.

Here, briefly, is what the Honeywell Periodic Service Plan does. It provides you—

Periodic examination and adjustment by a factory-trained service engineer.

Automatic attention. Calls are made on a schedule that fits your own plant's requirements . . . at a cost substantially lower than an equivalent emergency service call.

Continuous operation. Good instruments kept in top condition can be counted on for steady duty, without costly shut-downs. Well-maintained instruments last longer, too.

Increased plant efficiency. Greater reliability of operation builds confidence of plant personnel in their equipment.

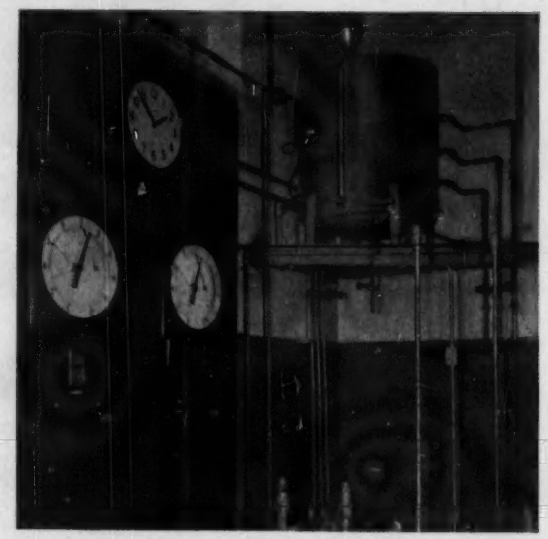
At any time, of course, you can count on prompt emergency service from any one of the more than 100 Honeywell service centers spotted throughout the United States and Canada.

The Plan is extremely simple. It costs remarkably little, and can pay real dividends in protection of your production schedules and your instrument investment. For details about how it can be applied to your own plant, call your local Honeywell office.

Water treating . . .

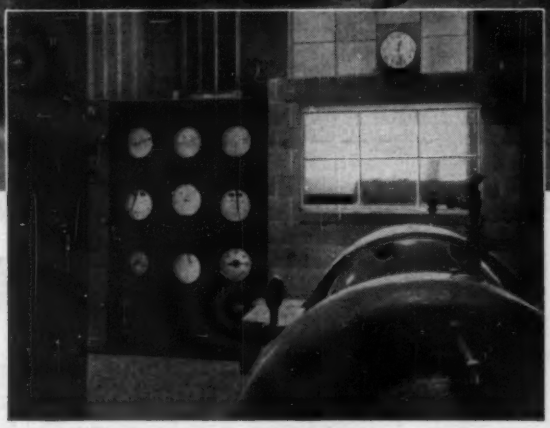
reduced to routine supervision

by Honeywell



Shown on the water treatment control panel at James Lees and Sons Co., Bridgeport, Pa., are two ElectroniK pH indicator-recorders, one with Electr-O-Line control for the caustic feeding system.

Water treatment plant at the Alan Wood Steel Co., Conshohocken, Pa. In the pump room, Honeywell flow meters, level and pressure gages control the flow of recirculated mill and river water through the treatment process.



instrumentation

At the Alan Wood Steel plant, Honeywell instrumentation was applied to treat waste, as well as to condition incoming river water for mill requirements—a total of 20 million gallons per day. Overall plant efficiency is increased, and maintenance is reduced. By providing a constant supply of uniform water, Honeywell controls effect savings throughout the plant, and permit closer control of process temperatures and pressures. Controlled waste discharge contributes to good community relations.

At the James Lees and Sons plant, water is supplied at the rate of a million gallons per day from the highly turbid Schuylkill River. Until Honeywell instrumentation was installed, variations in volume, turbidity, percentage of suspended solids and concentration of pollutants posed serious troubles. Now, Honeywell controls provide consistently clear water at pH 8. Alum requirements have dropped 90%. Double shifts are no longer needed in the treatment plant. Night and Sunday trouble-shooting by the superintendent is eliminated.

You can save time, trouble and materials—and end water treatment difficulties—with Honeywell automatic controls. Two cases in point: a textile plant with the problem of treating incoming river water, and a steel mill requiring special treatment of both incoming water and waste. In both instances, Honeywell controls provided profitable solutions.

Honeywell instrumentation is now serving in hundreds of industrial and municipal water treatment and waste discharge processes. In every case, it offers closer control and higher efficiency of water treatment. Regardless of your specific need, Honeywell instrumentation can save you money, both directly and in end benefits. Contact your nearby Honeywell sales engineer for help with your water or waste treatment problems . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

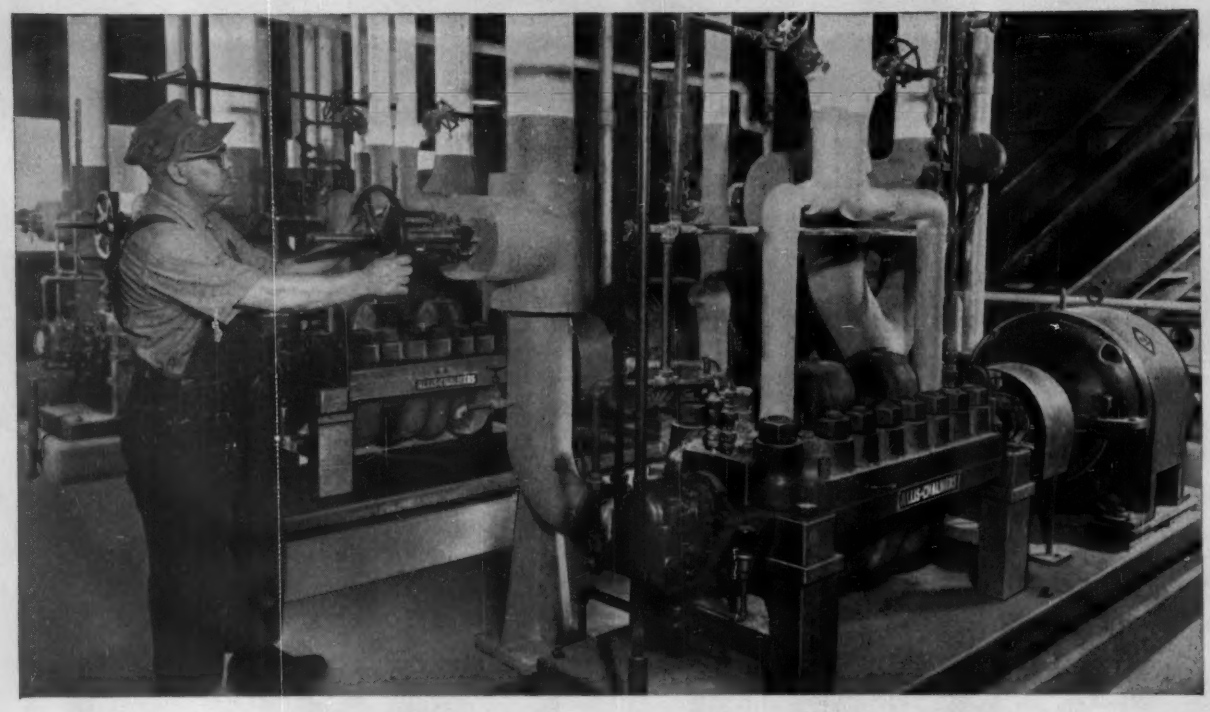
H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

Allis-Chalmers Pumps Meet Power Plant Requirements



New Pumps Give Milwaukee County Institutions

. . . Dependable Power Service

THESE modern multi-stage high pressure pumps assure continuous, economical steam for the Allis-Chalmers 3000-kw steam turbine units at the Milwaukee County Institutions.

As new members of the Allis-Chalmers complete line of pumps, these units are designed to meet medium-high pressure, continuous service requirements of boiler feed duty in lower volume ratings.

Horizontally split casing with suction and discharge in lower half provide for simplified maintenance—without disturbing piping. Both radial and axial balance maintains close clearances and fits, gives low thrust bearing loads. Bearings are double-row ball bearings or alternate sleeve bearing with Kingsbury thrust. Sleeve and Kingsbury combinations have ring oiling as well as pressure lubrication.

You get **MORE** than a Pump . . . When You Specify Allis-Chalmers

You can take advantage of Allis-Chalmers wide experience in supplying pumps to all industries. You are assured of modern design, heavy duty construction and correct application aid — all adding up to years of dependable service.

Allis-Chalmers is the only company that can offer you "One-Source" responsibility, with a complete unit — pump, motor and control — all built to work together. For "MORE" information about Allis-Chalmers pumps, call your local A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-5098

R.V.S.
Edward has the original and only complete line of carbon and stainless steel all-forged instrument valves. These features will save us money.
B. J. B.

ROCKWELL BUILT
Edward Valves

Bronze yoke bushing and fine stem threads wear longer, operate easier, adjust flow better.

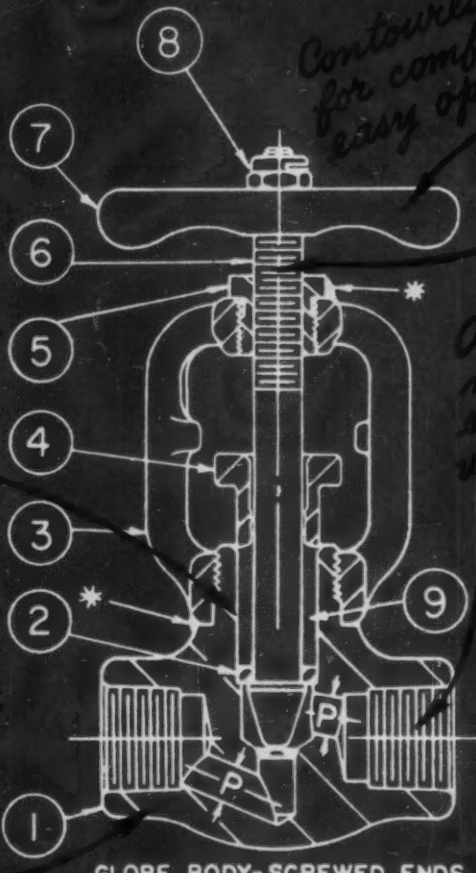
Contoured "T" handle for comfortable, easy operation.

Deep packing chamber high grade packing combine to minimize maintenance.

Drop forged heat-treated body provides strength and freedom from porosity without excess weight.

Accurately machined screwed or socket welding ends.

Let's have Edward supply all instrument valves and other steel valves on our new units.



GLOBE BODY-SCREWED ENDS

LIST OF MATERIAL
QUANTITIES ARE FOR ONE GLOBE OR ONE ANGLE VALVE
WHERE A.S.T.M SPECIFICATIONS ARE INDICATED THE LATEST REVISION APPLIES

PIECE NO.	NAME OF PIECE	NO. REQ'D	MATERIAL	SPECIFICATIONS	EDW MS NO
1	BODY	1	FORGED STEEL 0.30% MAX. C	A.I.S.I. C1029	114
2	JUNK RING	1	EVALLOY	A.S.T.M.A182 GRADE F6	212
3	YOKE	1	FORGED STEEL	A.S.T.M.A105 GRADE II	111
4	GLAND	1	FORGED STEEL EVALIZED	A.S.T.M.A105 GRADE II	111
5	YOKE BUSHING	1	BRONZE	A.S.T.M.B21	442
6	STEM	1	STAINLESS STEEL 13% CHROMIUM	A.I.S.I. TYPE 416	219
7	T-HANDLE	1	MALLEABLE IRON	A.S.T.M.A47 GRADE 32510	322
8	LOCK NUT	1	STEEL	COMMERCIAL	
9	PACKING		EVALPAK	HIGH TEMPERATURE PACKING	501
10	GLAND BOLT	2	FORGED STEEL EVALIZED	A.I.S.I. C1120	123
11	BOLT WASHER	2	STEEL		
12	BOLT NUT	2	STEEL-EVALIZED	A.S.T.M.A194 CLASS O	124
13	DISK	1	STAINLESS STEEL WITH STELLITED SEATING FACE	A.S.T.M.A193 GRADE B8F	257 481

EDWARD VALVES, INC.
SUBSIDIARY OF ROCKWELL MANUFACTURING CO.
EAST CHICAGO, INDIANA

FORGED STEEL INSTRUMENT
GLOBE AND ANGLE VALVES
GENERAL ASSEMBLY

DRAWN: [illegible]
CHK'D: [illegible]
APP'D [illegible] DATE: 12-19-[illegible]

CE-3430

Edward builds Globe and Angle Stop, Non-Return, Check, Stop-Check, Gate, Blow-Off, Mudline, Relief, Hydraulic, Instrument, Gage, and Special Valves and Strainers.

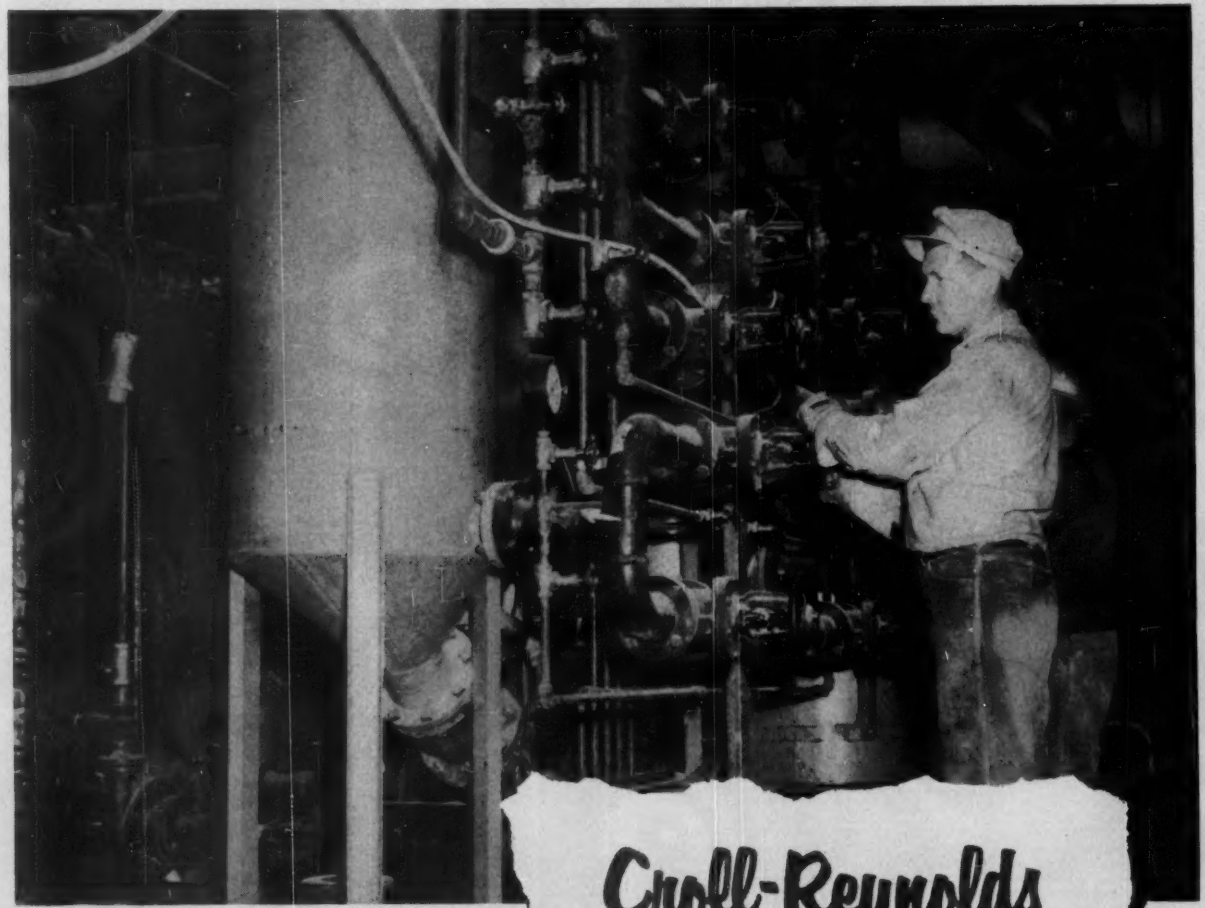
CLARITE FILTERS PURIFY FEEDWATER FOR FIRST SUPERCRITICAL PLANT

The American Gas & Electric Service Corp., in conjunction with General Electric and Babcock & Wilcox, has designed and built a supercritical pressure steam electric generating unit to increase the capacity of their Ohio Power Co. plant at Philo, Ohio.

It is a two-stage reheat unit of 125 Mw capacity, operating at 4,500 p.s.i. and 1,150°F. This new design yields greatly increased thermal efficiency, with resultant savings in fuel costs.

Feedwater specifications called for 500 ppb maximum dissolved solids and 10 ppb maximum iron. Croll-Reynolds tubular "wedge wire" membrane-type filters were selected for use with cellulose precoat media to protect the demineralizer equipment from being fouled by Iron Oxide. These highly efficient C-R ClaRite filters reduce the iron content of the condensate to 1 ppb . . . *9 ppb less than the maximum specified!*

C-R ClaRite Filters are engineered to handle any and all pressure clarification problems, with minimum maintenance and operating expense. Further information may be obtained from:



Croll-Reynolds condensate filter system at Philo Plant's Unit 6. Two C-R ClaRite Filters with a combined filter area of 100 sq. ft. remove iron oxide particles down to a fraction of a micron in size from 200 gpm of condensate.

Croll-Reynolds

ENGINEERING CO., INC.

15-17 John Street, New York 38, N.Y.

Representatives in Principal Cities

J.B.—
These "Special" features are standard on 1500 and 2500 lb Edward Univalves.
R.J.P.

All forged construction— No porous castings here.

Impactor handle provides tight closing. No need for cheater.

Let's have Edward quote. Quality and performance are important

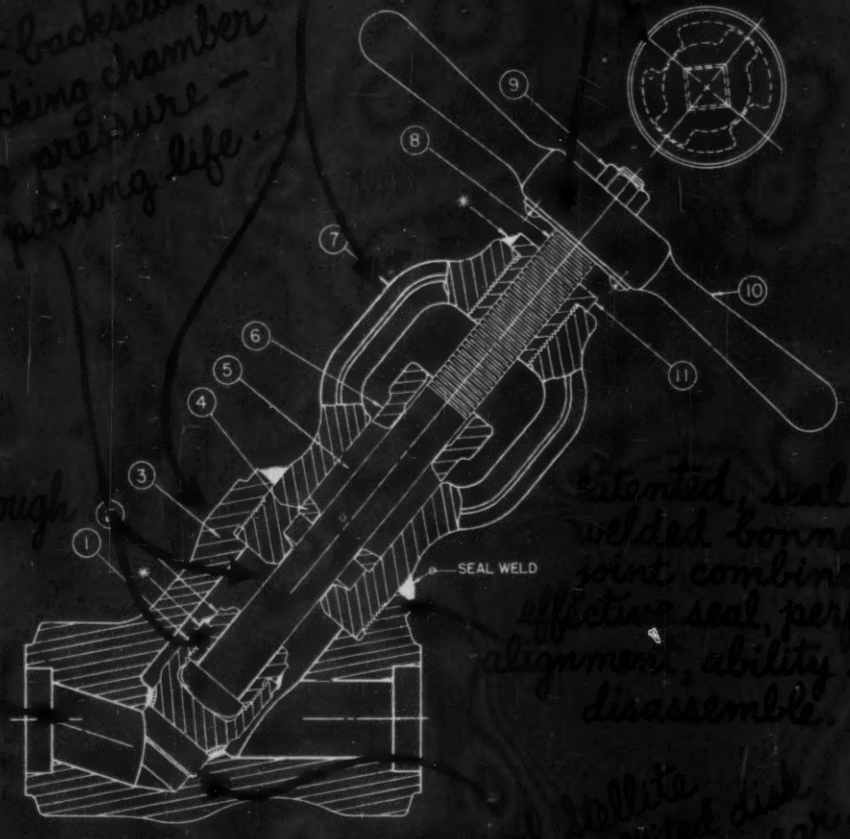
Line contact backseat isolates packing chamber from line pressure— prolongs packing life.

Straight-through design minimizes erosive wear due to turbulent flow— extends life.

Patented, seal-welded bonnet joint combines effective seal, perfect alignment, ability to disassemble.

Integral Stellite seat & Stellited disk for wear.

ROCKWELL BUILT
Edward Valves



LIST OF MATERIAL
QUANTITIES ARE FOR ONE GLOBE OR ONE ANGLE VALVE
WHERE A.S.T.M. SPECIFICATIONS ARE INDICATED THE LATEST REVISION APPLIES

PIECE NO.	NAME OF PIECE	NO. REQ'D.	MATERIAL	SPECIFICATIONS	EDWARD MS NO.
1	DISK	1	FORGED STEEL	A.S.T.M. A182 GRADE F11	227
2	DISK NUT	1	EVALLOY	A.S.T.M. A182 GRADE F6	212
3	BODY	1	FORGED ALLOY STEEL	A.S.T.M. A182 GRADE F11 (b)	227
				A.S.T.M. A182 GRADE F22 (c)	230
4	JUNK RING	1	STEEL-EVALIZED	A.I.S.I. C1120	123
5	PACKING RINGS		EVALPAK	HIGH TEMPERATURE PACKING	501
6	GLAND	1	FORGED STEEL	A.S.T.M. A105 GRADE II	111
7	BONNET	1	FORGED ALLOY STEEL	A.S.T.M. A182 GRADE F11 (b)	227
				A.S.T.M. A182 GRADE F22 (c)	230
8	STEM	1	EVALLOY	A.I.S.I. GRADE 416	261
9	STEM NUT	1	STEEL	A.S.T.M. A194 CLASS 1 OR 2	124
10	IMPACTOR HANDLE	1	MALLEABLE IRON	A.S.T.M. A47 GRADE 32510	122
11	YOKE BUSHING	1	BRONZE	A.S.T.M. B148 GRADE 9B MT	432
12	GLAND BOLT NUT	2	STEEL	A.S.T.M. A194 CLASS 1 OR 2	124
13	GLAND STUD	2	STEEL	A.S.T.M. A193 GRADE B7	205
14	GLAND BOLT LOCKNUTS	4	STEEL	A.S.T.M. A194 CLASS 1 OR 2	124

EDWARD VALVES, INC.
SUBSIDIARY OF ROCKWELL MANUFACTURING CO.
EAST CHICAGO, INDIANA

FORGED STEEL UNIVALVES
GENERAL ASSEMBLY
FIG.-3924 SIZES ½, ¾, 1, 1¼, 1½, 2

DRAWN: A. D. L.
CHK'D: J. Piet
APP'D: [illegible] DATE: [illegible]

DRAWING NO. AE-3593-1

Edward builds Globe and Angle Stop, Non-Return, Check, Stop-Check, Gate, Blow-Off, Mudline, Relief, Hydraulic, Instrument, Gage, and Special Valves and Strainers.

First
Research-Cottrell
"Double-Deck"
Fly Ash Precipitator

Space was a big problem in this installation at the Burlington Generating Station of Public Service Electric and Gas Company of New Jersey. Two integral combination mechanical-electrical precipitators, large enough to handle 600,000 cfm of gas from Boiler No. 7, had to be squeezed into the smallest possible ground area.

If a conventional side-by-side arrangement had been used, these two units would have required about 1,700 square feet. By "stacking" the two combination precipitators, one on top of the other, Research was able to cut this space requirement by 50% — a saving of 850 square feet.

Although this arrangement had never been attempted with Research fly ash precipitators, Research knew from their experience with more than 500 central station Cottrells that it could be done. Guaranteed for 97% collection efficiency, these Burlington Generating Station units were placed in operation in October, 1955.

Perhaps you, too, have a knotty problem that demands a more creative approach — backed up by experience with over 500 fly ash precipitators. Whether you require a straight precipitator or a combination unit, at Research-Cottrell you can be sure of the most economical solution to your problem.

Other Research-Cottrell Precipitators at Public Service Electric and Gas Company of New Jersey

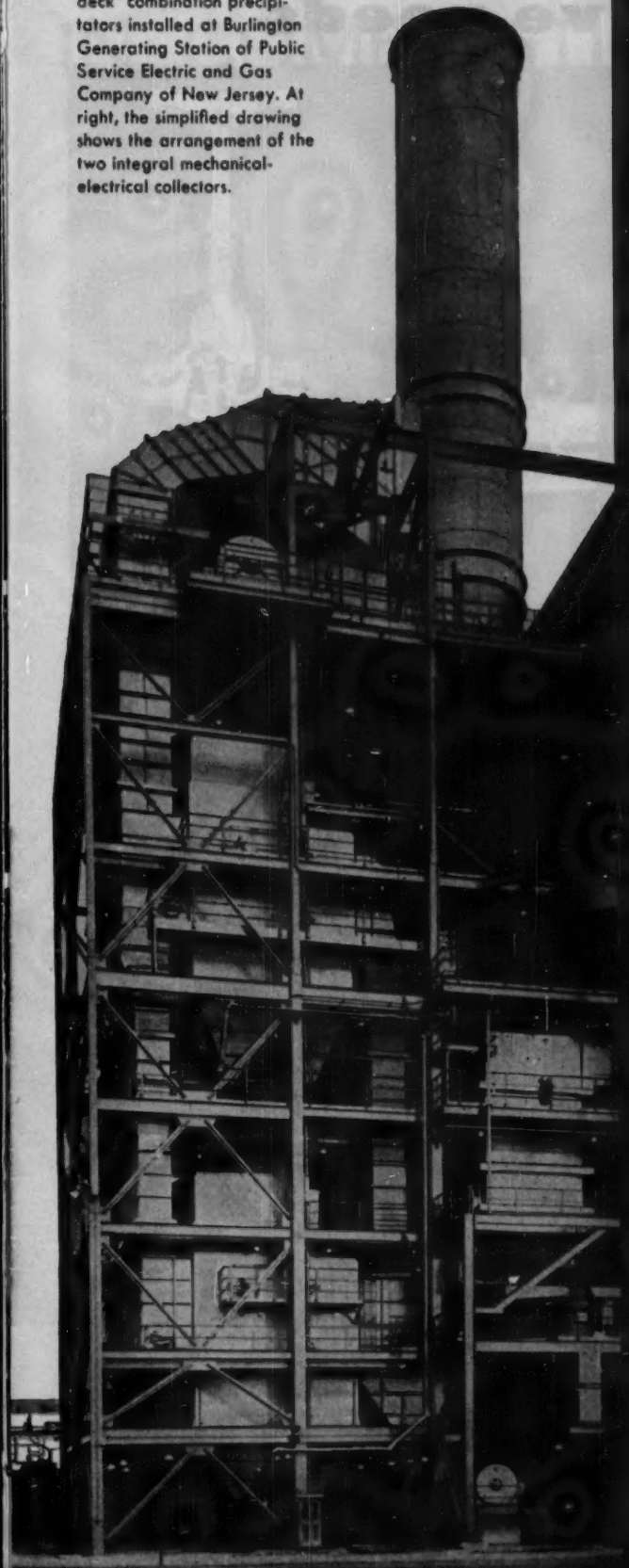
Installation Date	Generating Station	Boiler Number	Number of Pptrs.	C. F. M.
1937	Burlington	11	1	270,000
1938	Essex (Newark)	25 and 26	4	520,000
1940	Burlington	12 and 13	2	448,000
1941	Marion (Jersey City)	51 and 52	2	448,000
1942	Burlington	14 and 15	2	448,000
1946	Kearny	1 (Mercury Blr.)	1	160,000
1947	Essex (Newark)	1	3	380,000
1955	Burlington	7	2*	600,000
		Total	17	3,274,000

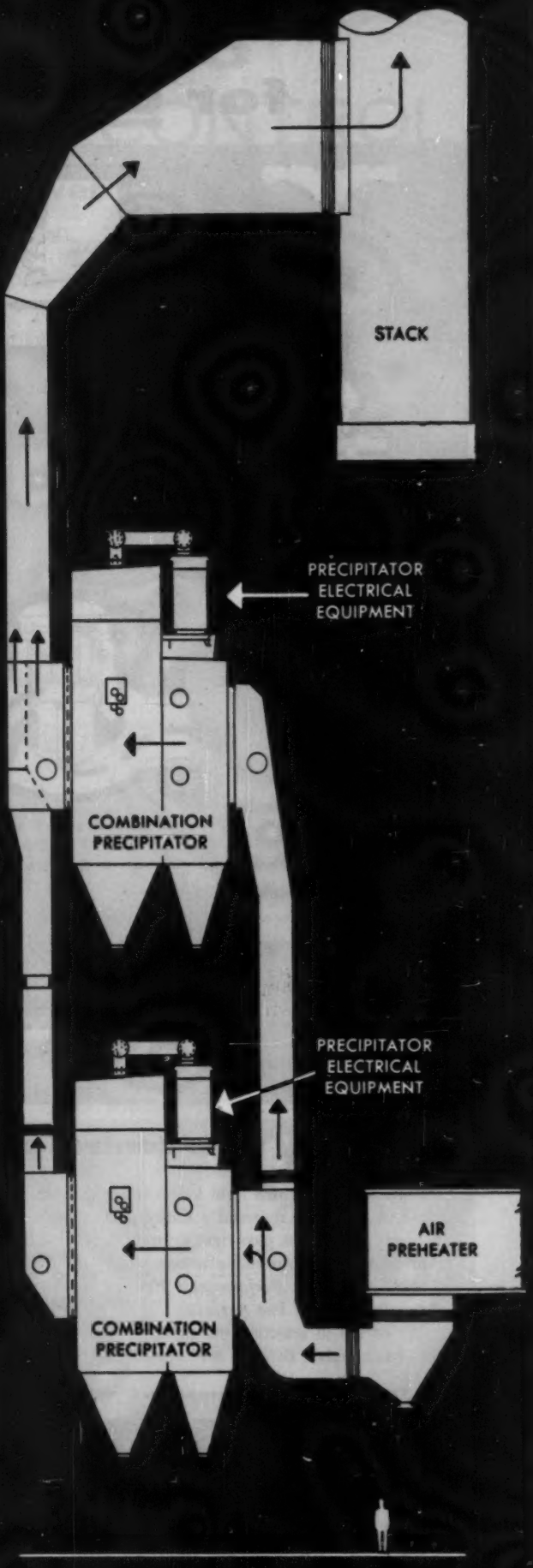
*"Double-Deck" Arrangement

Research-Cottrell, Inc.

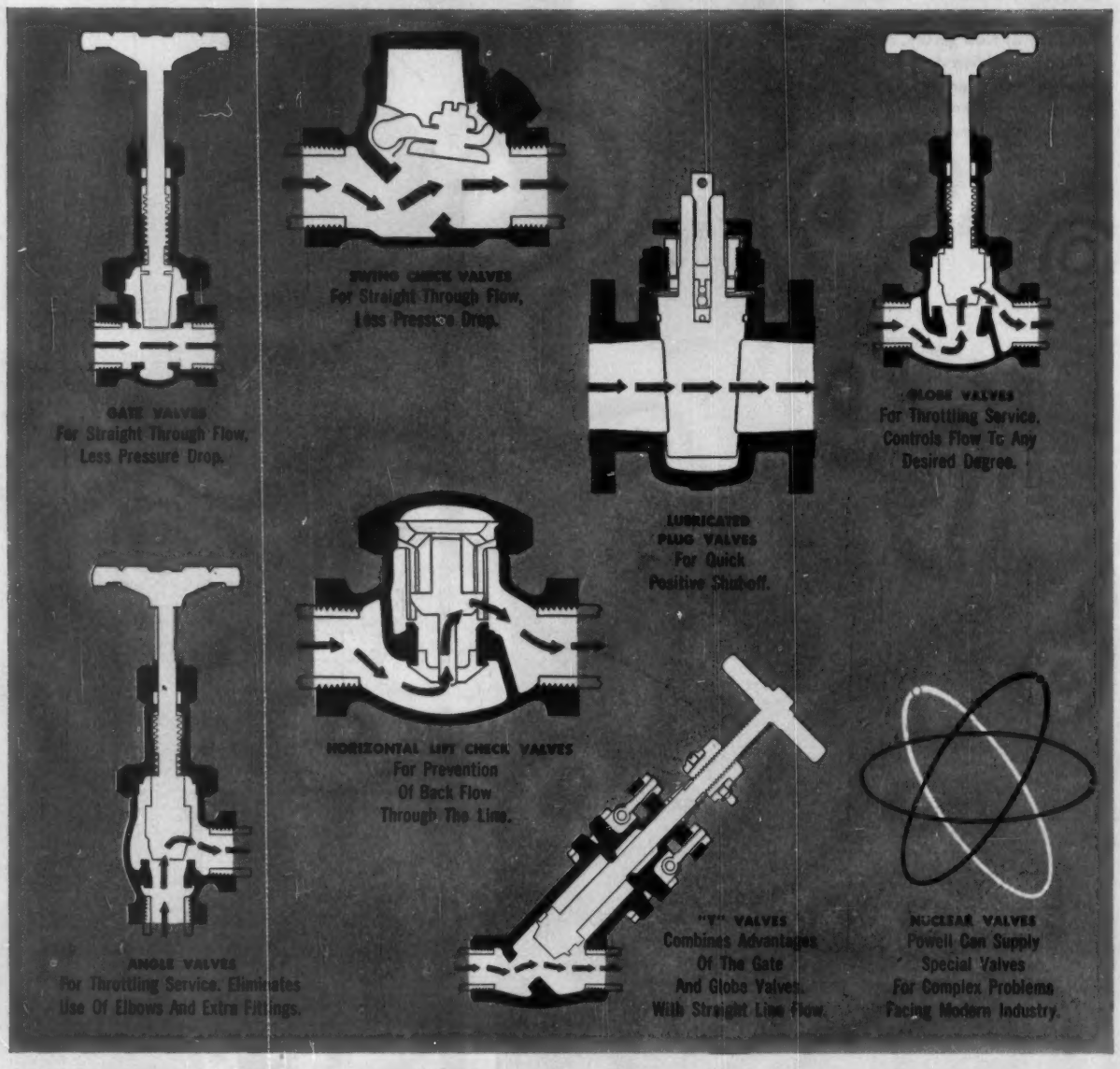
Main Office and Plant: Bound Brook, New Jersey • 405 Lexington Ave., New York 17, N. Y.
Grant Building, Pittsburgh 19, Penna., 228 No. La Salle St., Chicago 1, Ill. • 111 Sutter Bldg., San Francisco 4, Cal.

Research-Cottrell's "double-deck" combination precipitators installed at Burlington Generating Station of Public Service Electric and Gas Company of New Jersey. At right, the simplified drawing shows the arrangement of the two integral mechanical-electrical collectors.





POWELL
for all valve needs



for every flow control problem there is a right Valve

Powell can supply this right valve—*made right* of the right material*. Every part of every valve must pass rigid inspection. And as a final step in manufacture, every Powell Valve has *Performance Verified* through an *actual line test.*

As an aid in selecting the right valve, the basic valve designs are illustrated here. For complete information on the wide range of sizes and materials available in each type of the basic valves illustrated above, consult your Powell Valve distributor. If none is located near you—or if you have a special flow control problem—write direct to The Wm. Powell Company, Cincinnati 22, Ohio.

PERFORMANCE
PV
VERIFIED

The Wm. Powell Company, Cincinnati 22, Ohio . . . 110th YEAR

POWELL VALVES

*BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES.

NEW DIMENSIONS
IN COMBUSTION CONTROL

For the largest to the smallest power plants

Today's boiler plant is only as efficient as the instrumentation which operates it. In selecting the correct equipment to assure completely automatic operation, to provide cost reductions through labor saving, and greater efficiency, the companies shown on these pages have looked to Hays. The newest in power plant design coupled with Hays workmanship and follow-through have given them the results they sought.

SKILLED FACTORY ENGINEERING

Hays systems are engineered to your specific requirements by a staff of specialists with years of experience on hundreds of boiler plants from the smallest to the largest. The particular instrument and control "package" necessary to handle your conditions is selected from the Hays product line; panel design, complete wiring, conduit, piping and control system diagrams are closely checked to see that they fit your requirements.

NATIONWIDE SERVICE

Service on Hays products is available throughout the country. Trained service engineers, from the factory or from Hays representatives in principal cities, can provide "start up" calibration and adjustment as well as subsequent periodic preventive maintenance service on your equipment.

For best results you will want to confer with Hays Sales Engineers in the earliest stages of your planning.

Write for complete information. Bulletin 55-605-83.

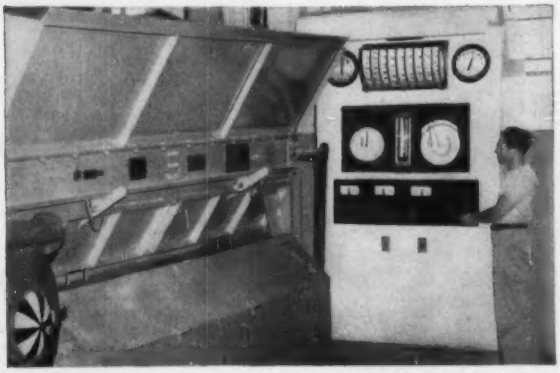
THE **hays** CORPORATION

MICHIGAN CITY, 3, INDIANA

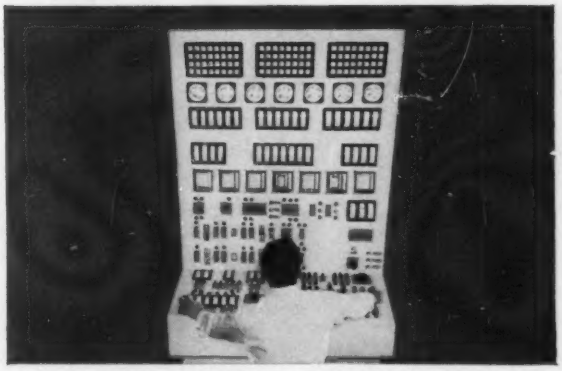
Automatic Combustion Control • Veriflow Meters and Veritrol • Electronic Oxygen Recorders • CO_2 Recorders Boiler Panels • Gas Analyzers • Combustion Test Sets Draft Gages • Electronic Flowmeters • Miniature Remote Indicators • Electronic Feed Water Controls

At Baldwin Locomotive Works, the Hays combustion control has aided substantially in saving 30,000 tons of coal per year and in reduction of maintenance. It is now possible to operate the power plant with 42 less men.

At Morton Salt Company, Manistee, Michigan, the fact that electricity doesn't freeze is vital in this semi-outdoor boiler which handles load swings up to 80,000 lb/hr at 85% efficiency with help of Hays electrically operated combustion control system.

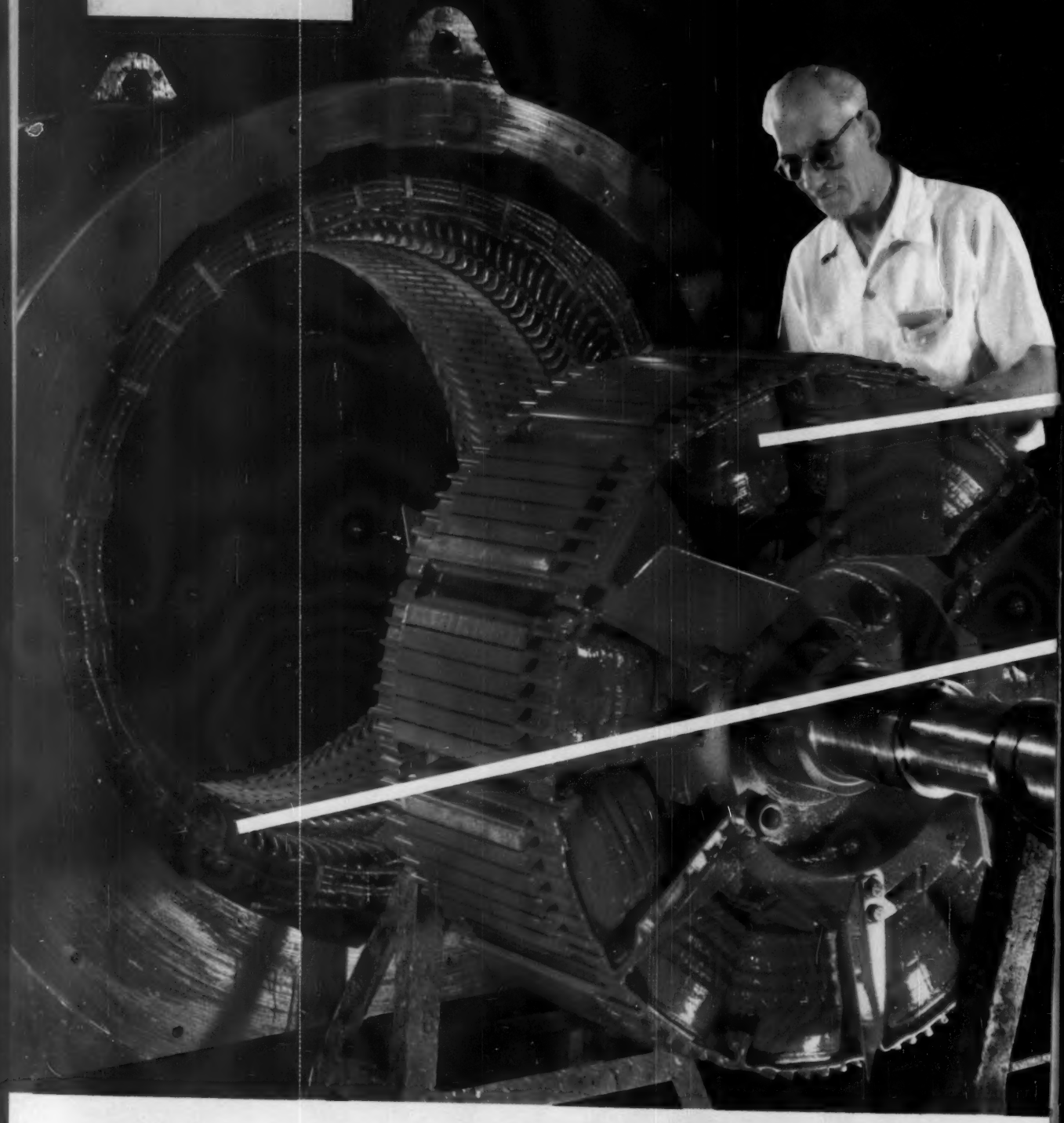


At Falstaff Brewing Corporation, modernization and Hays metering type control have resulted in boiler efficiency of 82%, fuel cost reduction of several hundred dollars per month, CO_2 up from 6% to 12%, and maintenance costs lowered 65%.



At Louisiana Power and Light, a compact Hays B. T. G. control panel only 4 feet wide controls a giant 1,000,000 lb/hr boiler, turbine and generator! Instrumentation and control by Hays includes electronic mercuryless flow meters and other electronic instruments.

ONLY Allis-Chalmers



ALLIS-

MOTORS are "double protected"

New Integrated Field Coils Plus *Silco-Flex* Stator Insulation Provide Superior Motor Protection... Under Any Operating Conditions

1

Integrated Field Coils are bonded in heat-stabilized resins, enclosed in a resin-impregnated sheath of oriented glass fibers and bond-locked on the pole structure . . . dimensionally stable to withstand heating and thermal shock, vibration and fatigue at elevated temperatures . . . sealed throughout against atmospheric contaminants and fully protected against destructive forces.

2

***Silco-Flex* Insulation** provides a homogeneous, void-free insulating wall of silicone rubber on stator coils. It is unexcelled in life and thermal stability at high temperatures . . . resistant to most chemicals, water, weather . . . outstanding in flexibility and resilience . . . able to withstand abrasion and corona . . . resistant to physical and mechanical forces.

Exclusive Allis-Chalmers "double protection" is available on large electrical machines with operating temperatures through Class B range.

Silco-Flex is an Allis-Chalmers trademark

For more information on these quality insulation systems contact your nearby A-C office, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin for Integrated Field Coil Bulletin 05R8525 and *Silco-Flex* Insulation Bulletin 05R8341.

Allis-Chalmers "Double Protection" with integrated field coils and Silco-Flex stator coil insulation, adapts this 600-hp, 2300-volt, 600-rpm synchronous motor to the most severe operating conditions.

CHALMERS

A-C ALLIS-CHALMERS

A-5221

ALL 100

General Motors • Standard Oil (N.J.) • Ford Motor • U.S. Steel • Chrysler • General Electric • Swift • Bethlehem Steel • Armour • Du Pont (E.I.) de Nemours • Gulf Oil • Western Electric • Socony Mobil Oil • Standard Oil (Ind.) • Texas Co. • Shell Oil • Westinghouse Electric Goodyear Tire & Rubber • Standard Oil of California • National Dairy Products • Republic Steel • Union Carbide & Carbon • International Harvester Firestone Tire & Rubber • Sinclair Oil • Radio Corp. of America • Procter & Gamble • U. S. Rubber • Cities Service • Phillips Petroleum • Douglas Aircraft • Boeing Airplane • Aluminum Co. of America • General Foods • North American Aviation • Borden • International Paper • Goodrich (B.F.) American Can • Eastman Kodak • United Aircraft Corp. • Jones & Laughlin Steel • Armco Steel • Sperry Rand • General Dynamics • Lockheed Aircraft • Continental Can • Sun Oil • American Metal • Inland Steel • Wilson & Co. • Anaconda Co. • Allied Chemical & Dye • National Steel Corp. • Youngstown Sheet & Tube • American Tobacco • Pittsburgh Plate Glass • Bendix Aviation • Internat. Business Machines • Olin Mathieson Chemical • Borg-Warner • Kennecott Copper • Republic Aviation • American Smelting & Refining • Allis-Chalmers • National Lead • Continental Oil Caterpillar Tractor • Monsanto Chemical • Burlington Industries • General Mills • Atlantic Refining • Curtiss-Wright • Pure Oil • Studebaker-Packard Tide Water Associated Oil • Dow Chemical • Reynolds (R.J.) Tobacco • American Cyanamid • Internat. Tel. & Tel. • American Motors • Grace (W.R.) Crown Zellerbach • Standard Brands • National Biscuit • Foremost Dairies • Ralston Purina • Reynolds Metals • Campbell Soup • Philco • Owens-Illinois Glass • Merritt-Chapman & Scott • Union Oil • Singer Manufacturing • Phelps Dodge • United Merchants & Manufacturers • Pillsbury Mills Standard Oil (Ohio) • American Radiator & Standard Sanitary • Deere

of America's 100 largest industrial corporations are users of Clarage air handling and conditioning equipment.

CLARAGE FAN COMPANY
KALAMAZOO • MICHIGAN

Source: The Fortune Directory • Published July 1956

Tough valve buyers appreciate this kind of... Toughness

*HAYNES STELLITE

Here's why:—They know that to foil those troublesome valve "termites"—erosion, corrosion, and galling—requires built-in toughness which only seats faced with hard facing alloys AND hardened wedges can provide. Yes, it takes BOTH to do a real job and GP Valves provide both at no extra cost!

Vogt GP Valves feature the toughest and, since they are precision finished, the smoothest seating surfaces obtainable anywhere. That's why they are setting new standards of performance—longer, drop-tight service with minimum, low cost maintenance—in petroleum refineries, chemical plants, power plants and other industries. Available in a complete range of sizes from ¼" to 2" and rated 800 pounds at 850° F. and 2000 pounds at 100° F.

Advt. No. 5 in a series describing the features of Vogt GP Valves.

Write For Your FREE COPY of Supplement No. 1 to Catalog F-9. Address Dept. 24A-FP

HENRY VOGT MACHINE CO.
P. O. Box 1918—Louisville 1, Ky.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati.

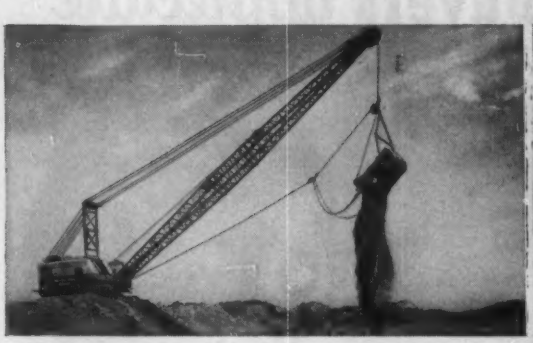
Vogt GENERAL GP PURPOSE Vogt FOR BETTER VALVES

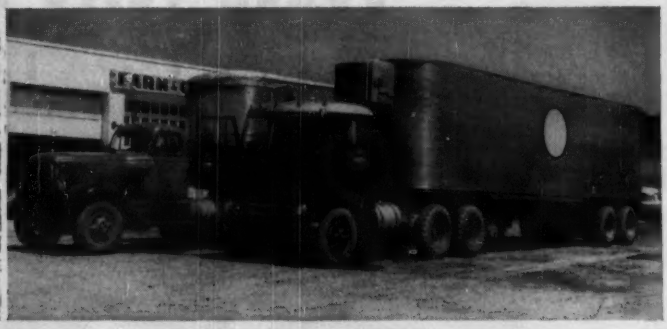
DROP FORGED STEEL

VALVES

HAYNES STELLITE—Trade-mark of Union Carbide and Carbon Corporation

For every type of diesel operation—





FOR MECHANIZED DIESELS, there's a Cities Service diesel oil for every operating condition. Most widely used is Cities Service C-300 Motor Oil, which has improved performance and lowered maintenance costs for a host of truckers, quarry operators, and mining men. Shovel above logged 16,280 hours with no repairs, no increase in oil consumption. A Cities Service Lubrication Engineer will gladly show how you can achieve similar results.

the right track to greater profits

FOR RAILROAD DIESELS, Cities Service now offers a brand new oil . . . Pacemaker RD-80. Proven superior by over 50 million miles of operation on major railroads, new Pacemaker RD-80 reduces oil consumption up to 10%, cuts engine deposits 200% better than previous oils. Also gives superior protection of ring belt area. According to a leading engine builder, its oxidation stability is "the best of any oil tested."

is Cities Service Diesel Oil!

FOR STATIONARY DIESELS, Cities Service C-300 Lube Oil has won high praise from numerous users. Example: Paulding Light and Water reports 16,587,402 H.P. hrs. without oil change; gets 23,205 BHP hrs. per gallon consumed! For more information, write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

J&L STEEL

Jones & Laughlin
Electric Resistance Welded
Pressure Tubing

QUALITY CONTROL—Jones & Laughlin, an integrated steel maker, controls every step of production from iron ore to finished tubing.

RIGID TESTING—most modern testing procedures, at every step of progress, assure maximum strength and safety standards. Users can be sure that every safeguard possible is used before a tube is certified to ASTM A178-55 or A214-55.

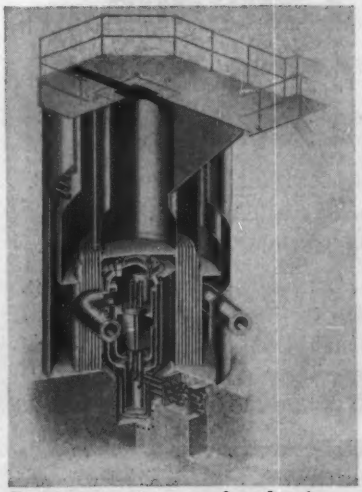
EASE OF FABRICATION—J&L pressure tubing can be fabricated according to your requirements.

For your next order, specify Jones & Laughlin pressure tubing for long life, maximum strength, clean appearance. Write for name of your nearest source.

Jones & Laughlin
STEEL CORPORATION · PITTSBURGH

Army Package Power Reactor (APPR) was designed and built by ALCO, *scheduled for completion in early 1957. Reactor will be operated at a heat rate of 10,000 Btu per second (10,000 kw). In construction at Fort Belvoir, Va., vapor container is at left, turbine room at right.*

YOU CAN GET ATOMIC POWER NOW



Reactor, reactor vessel and primary shielding of ALCO *APPR. Control rods and drive are shown top and bottom. Shielding consists of concentric steel cylinders with layer of water between each.*

ALCO's pressurized-water reactor plant is completely designed and engineered; scheduled for operation in early 1957. Similar plants can be purchased to generate commercial power.

Early next year, ALCO's atomic power plant will be in operation generating reliable power. ALCO is building the plant under the first fixed-price reactor contract awarded by the Atomic Energy Commission. Similar plants are available now to generate commercial power.

Design and engineering are complete. As a result, the cost of ALCO's atomic power plants, to about 12,000 kw, is lower than experimental reactors. ALCO's new nuclear criticality facility will further lower costs in reactor testing. Delivery time? Much faster than you'd expect.

Direct utilization of ALCO's atomic plants is economically justifiable in many locations where conventional fuel costs are high, transmission expensive or the location itself inaccessible. In such areas, an ALCO atomic power plant can mean a saving.

For full information relative to your specific project, you may contact your nearest ALCO sales office or write P. O. Box 1065, Schenectady 1, New York.

ALCO

ALCO PRODUCTS, INC.
NEW YORK

Locomotives · Diesel Engines · Nuclear Reactors · Heat Exchangers · Springs · Steel Pipe · Forgings · Weldments · Oil-Field Equipment

ALLIS-CHALMERS

ON THE JOB

Reporter finds solution to wide range of water problems

•Raw water is seldom suitable to meet specific requirements of the job. It usually needs some type of conditioning — best determined by a specialist. Here are typical examples of Allis-Chalmers water conditioning experience, equipment and chemicals in use.

Saved $22,000 First Year

Kansas—A chemical company plagued by high steam costs. Their boiler make-up water contained a high solids concentration, requiring a high blowdown rate.

After careful analysis of their problems, an Allis-Chalmers water conditioning engineer recommended Allis-Chalmers Anti-Foam. Use of this chemical resulted in increasing the solids concentration of the boiler water without carry-over. This, in turn, reduced the percentage of blowdown required.

Using A-C Anti-Foam, the company conservatively estimated first year savings of $22,000 in heat, water and chemicals.

* * *

Replacement of Condensate Return Lines Reduced to Practically Zero

Wisconsin—Here in one of the largest malt producing mills, several million pounds of steam are used daily for drying malt.

A special crew used to work all day every day doing nothing but replacing corroded condensate return lines. This, of course, was extremely costly.

Seven years ago, Allis-Chalmers water conditioning engineers were called in. Use of Allis-Chalmers No. 160 return line corrosion inhibitor was suggested.

Piping failures were reduced to the point where they only occur occasionally, and the maintenance crew has been assigned to other duties.

The Customer Is Always Right . . . Well, Most of the Time

East Coast — This plant had been using internal treatment of its boiler water. Chemical costs seemed excessive to management. After analyzing their own situation, they requested bids on a deionizer for treating makeup.

Instead of merely submitting a bid on the equipment specified, Allis-Chalmers engineers analyzed the water and the plant problem. This analysis showed that plant needs were such that a deionizer wasn't needed.

All that was needed was a de-alkalizer. Result: a savings of thousands of dollars.

* * *

The Case of the Dirty Dishes . . . or Don't Blame the Poor Dishwasher

Midwest — A harried plant cafeteria manager placed a frantic call to Allis-Chalmers water conditioning experts. Something was wrong. Glasses were spotty and plates had to be individually wiped off before they could be used. The grumbles were growing in the dining room . . . costs rising in the kitchen. His brand new $30,000 dishwasher wasn't getting the dishes clean, and the supplier of the dishwashing machine said the trouble was caused by the water.

The only trouble with that theory was that he had just installed a water softener the year before. The Allis-Chalmers water conditioning engineer examined the dishes coming out of the water and then asked to see the water softener. The problem was obviously hard water. The unit seemed to be in good working order and the tag indicated the softener had been recharged the previous day.

The maintenance man was called and asked to recharge the softener while an A-C engineer stood by. He went through all the steps—all but one, that is. He failed to close the bypass valve above the softener and practically none of the water went through the softener. It was then learned the operator was new and had not been properly trained.

Needless to say, the maintenance man is now an expert at operating the system, and everyone is pleased with the sparkling dishes.

Moral: A-C engineer's service covers the water front.

Expert Saves Steam for Drop Forge User

North Central — An Allis-Chalmers water conditioning engineer was called in by a manufacturer to supply water conditioning for makeup water. In checking the plant, here's what he found:

A large number of steam-operated drop forges are used by this company. The steam picked up oil from the pistons of the forge and was too contaminated for further use. It was dumped to waste.

He recommended installation of condensate oil removal filters. This was done and today practically all condensate is recovered. Makeup and water conditioning requirements are greatly reduced.

Problems Solved

For an answer to your industrial water problem, call the A-C office nearest you or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

WATER CONDITIONING • CHEMICALS, EQUIPMENT, SERVICE • FOR OVER 25 YEARS

A-C ALLIS-CHALMERS

A-5237

Got your tickets?

Reserved your room?

Planned your visit?

8th National PLANT MAINTENANCE & ENGINEERING SHOW and Conference

CLEVELAND PUBLIC AUDITORIUM
JANUARY 28-31, 1957

Attend the Conference, too . . .
One of the largest industrial conferences of its kind. Listen to the experts . . . top level discussion, conferences and panels on topics of prime importance to the maintenance and engineering executive.

Write for free tickets to the Show and information about the Conference to:

Plant Maintenance & Engineering Show
CLAPP & POLIAK, INC.
341 Madison Avenue
New York 17, New York

If your answer is YES you're ready to spend four of the most important days on your job in 1957

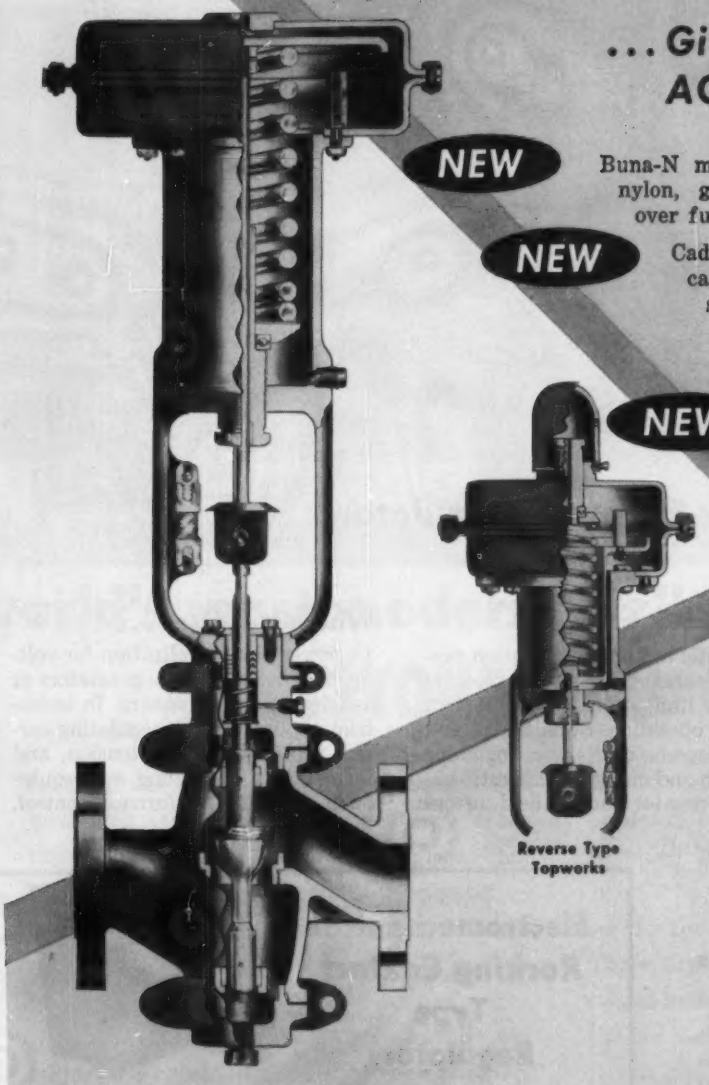
✓ In no other way can you see so many products and accumulate ideas to increase plant efficiency, reduce costs and increase production in the coming year.

✓ Over 400 leading manufacturers will exhibit everything in machines, equipment, supplies and services to answer the needs of your plant.

✓ Press buttons, pull levers, turn switches . . . see, touch, and try for yourself to help you evaluate and compare competitive products. Talk to the thousands of manufacturers' technical experts who can help you solve your problems. ***Plan now to attend!***

New BS&B Super 70 series TOPWORKS

... Give FAST, ACCURATE Response!



Reverse Type Topworks

NEW Buna-N moulded diaphragm, reinforced with nylon, gives uniform cross sectional thrust over full valve travel.

NEW Cadmium plated pressed steel diaphragm cases give maximum strength and corrosion resistance with minimum weight. Special chromate treatment provides superior bonding agent for paint and added corrosion protection.

NEW Bolted clamp ring device integrates body and topworks assemblies into a single unit, and permits yoke to be oriented to any convenient position for observation and action.

Four sizes of Super 70 Series Topworks are available in both direct and reverse acting types. Both are interchangeable on single port, double port, or split body styles. A single spring, precision calibrated to plus or minus 2% of rating, provides accurate travel response to changes in diaphragm loading pressure. (Reverse type topworks uses recessed spring). Ductile iron yoke provides the rigidity of cast iron and the safety of steel. All units use split and bolted stem connector and adjustable travel scale plate.

This advertisement highlights only features of the Super 70 Series Topworks. For information on the new valve bodies of the Super 70 Series line, ask for Catalog 70-11.

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

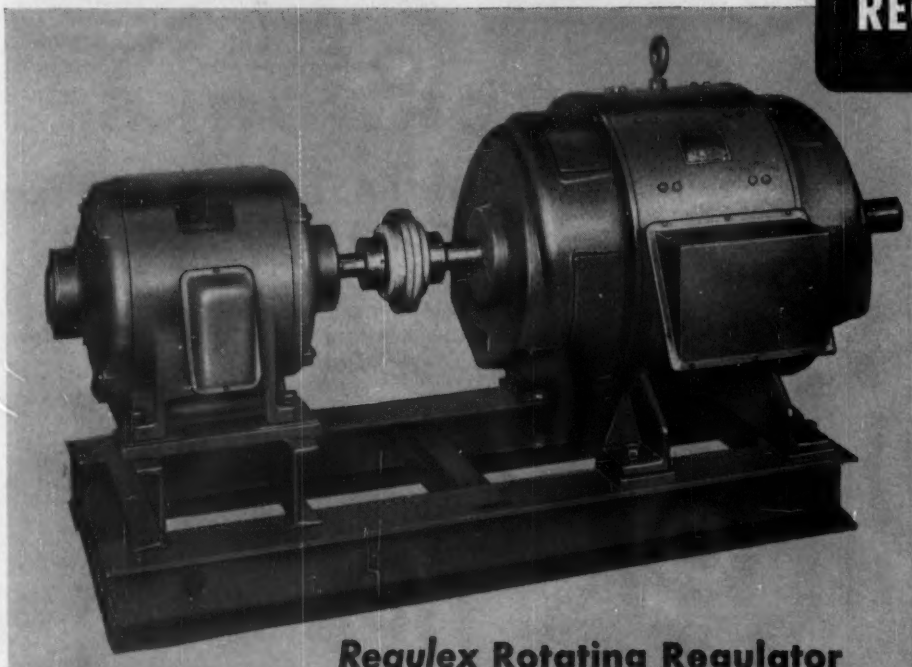
BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-Q12

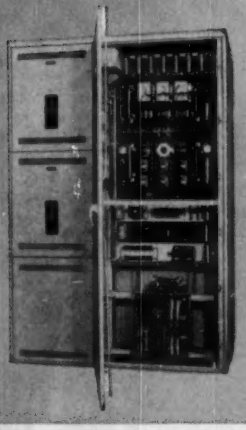
7500 East 12th Street Kansas City 26, Missouri

A Type and Size for Your Specific Needs

ALLIS-CHALMERS REGULATORS



Regulex Rotating Regulator



Regulex regulator consists of m-g set and cubicle containing static elements. Cubicle may be combined with switchgear.

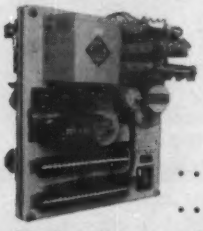
- Stability during high power-factor operations.
- Increased operating limits through automatic minimum excitation.
- High sensitivity and rapid response.

How It Works . . .

Automatic minimum excitation permits generator operation close to stability limit — much closer than manual operation. Sensitivity and quick response of *Regulex* regulator establish and maintain safe ratio between generator load and field current.

Where It Is Used . . .

In power plant application for voltage regulation of large generators or synchronous condensers. In industrial applications for regulating current, voltage, speed, tension, and reversing of processing mill equipment, and for arc-furnace control.



Magnetic AMPLIFIERS

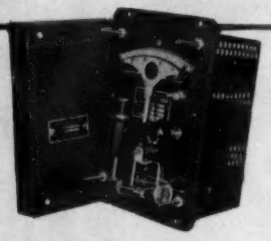
. . . Low maintenance

. . . High sensitivity

Designed for applications requiring high sensitivity and response, where regulator is subjected to shock, or where continuous performance is a prime factor. Used in conjunction with *Regulex* unit when reversed polarity output is required. Since the magnetic amplifier has no moving parts it requires little maintenance.

For complete information call your Allis-Chalmers representative, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

Electromechanical *Rocking Contact* Type Regulators



For voltage regulation of smaller ac and dc generators.

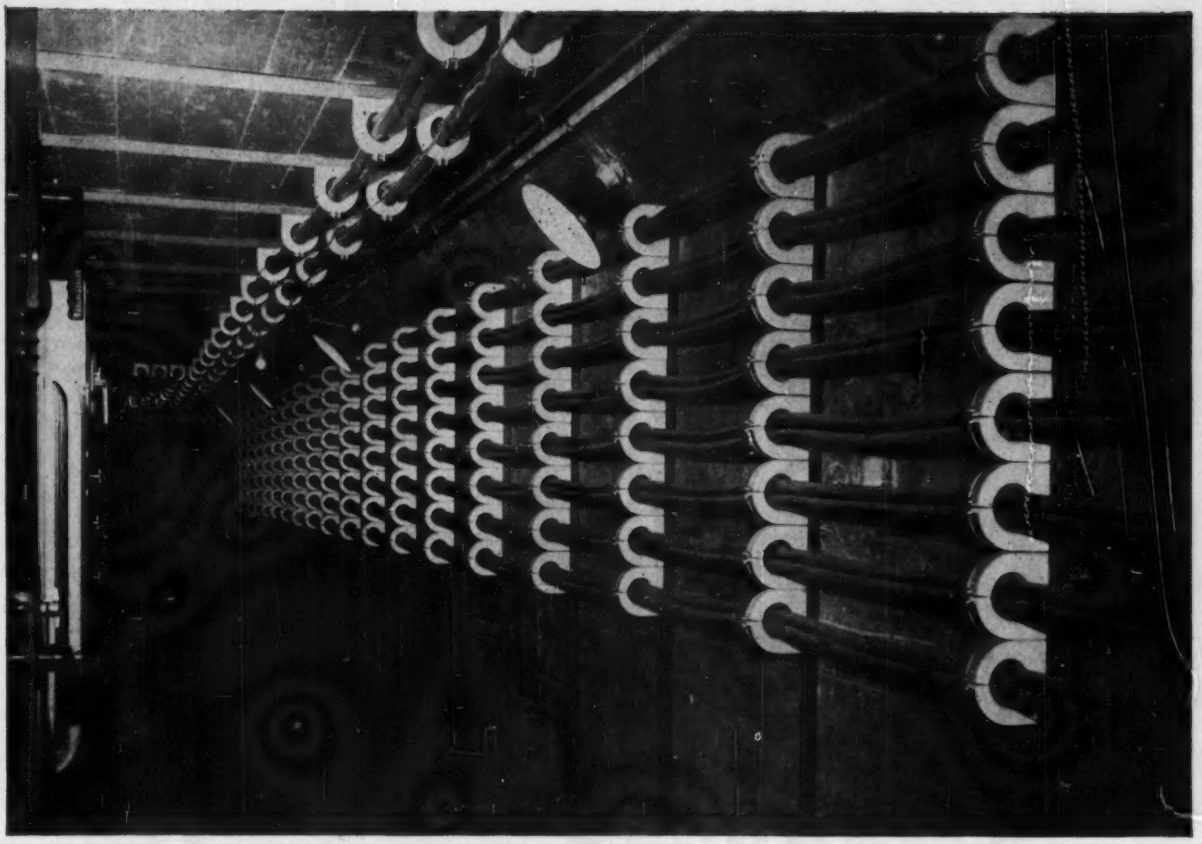
- Varies resistance in exciter shunt field by rocking action.
- Quick regulation over entire range with short movement.
- No sluggish relays.
- No vibrating or sliding contacts to wear.

Regulex and *Rocking Contact* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-3073



for maximum dependability . . .
world's most modern shell plant specifies
KEYSTONE 5KV CABLES

Nothing was spared to provide the surest and most adequate supply of electrical energy for the huge motors, pumps and other equipment that make the Scranton Ordnance Plant, operated by the United States Hoffman Machinery Corporation, the largest and most modern of its type in the world.

In production less than 18 months after the project was approved, the plant makes extensive use of Keystone insulated 5kv non-shielded cable.

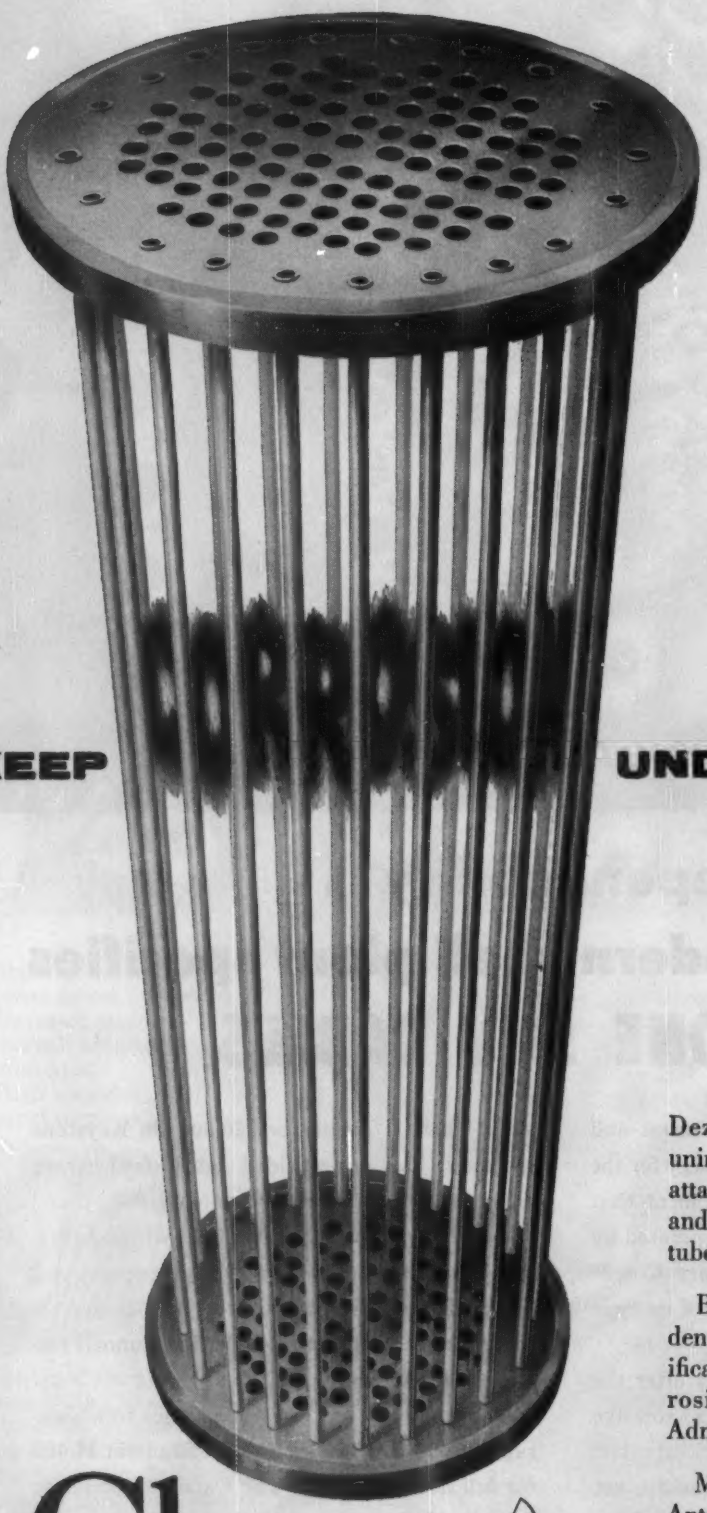
A typical application of this top-quality, yet economical cable is found in the plant's forge shop. There, 1/conductor 750,000 cm Keystone insulated 5kv non-shielded cables feed power from 3-5000 kva transformers to 12-600 hp and 12 - 450 hp pumps which provide hydraulic pressure for the main drawing and forging operations. These dependable power feeder cables are installed in interconnecting underfloor tunnels like the one shown above.

You, too, can use Keystone cables to advantage in your operation. Ask for Bulletin H-463 for full details or write The Okonite Company, Passaic, N. J.

2954-A

Available with either copper or aluminum conductors

where there's electrical power . . . there's **OKONITE CABLE**



KEEP CORROSION UNDER CONTROL...

with CHASE® Antimonial Admiralty Condenser Tubes!

Dezincification can make short work of uninhibited condenser tubes! It insidiously attacks the metal surface, dissolving the zinc and leaving porous copper behind until the tube wall is completely penetrated.

But Chase Antimonial Admiralty condenser tube is practically immune to dezincification! What's more, it retains *all* the corrosion resistant properties of ordinary Admiralty.

More than 100 million pounds of Chase Antimonial Admiralty tube have been installed to successfully combat dezincification, since Chase introduced this remarkable alloy in 1935. It may be just the alloy for you, too! Write for complete details.

Chase

BRASS & COPPER CO.

SUBSIDIARY OF KENNECOTT COPPER CORPORATION • WATERBURY 20, CONNECTICUT

The Nation's Headquarters for Brass, Copper and Stainless Steel

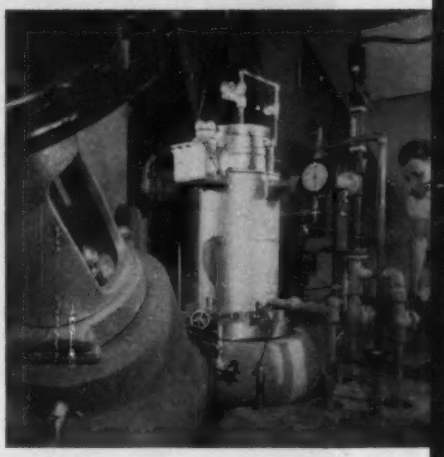
Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

Westinghouse "canned" pump eliminates leakage at VEPCO

Zero leakage! No injection water sealing required. Pump may be kept on hot or cold stand-by. No seal maintenance. Windings protected by nickel "cans" welded in place. No bearing lubrication.

These are advantages realized by Virginia Electric Power Company with the installation of a Westinghouse "canned" motor pump in the controlled circulation boiler system of the new Possum Point Station.

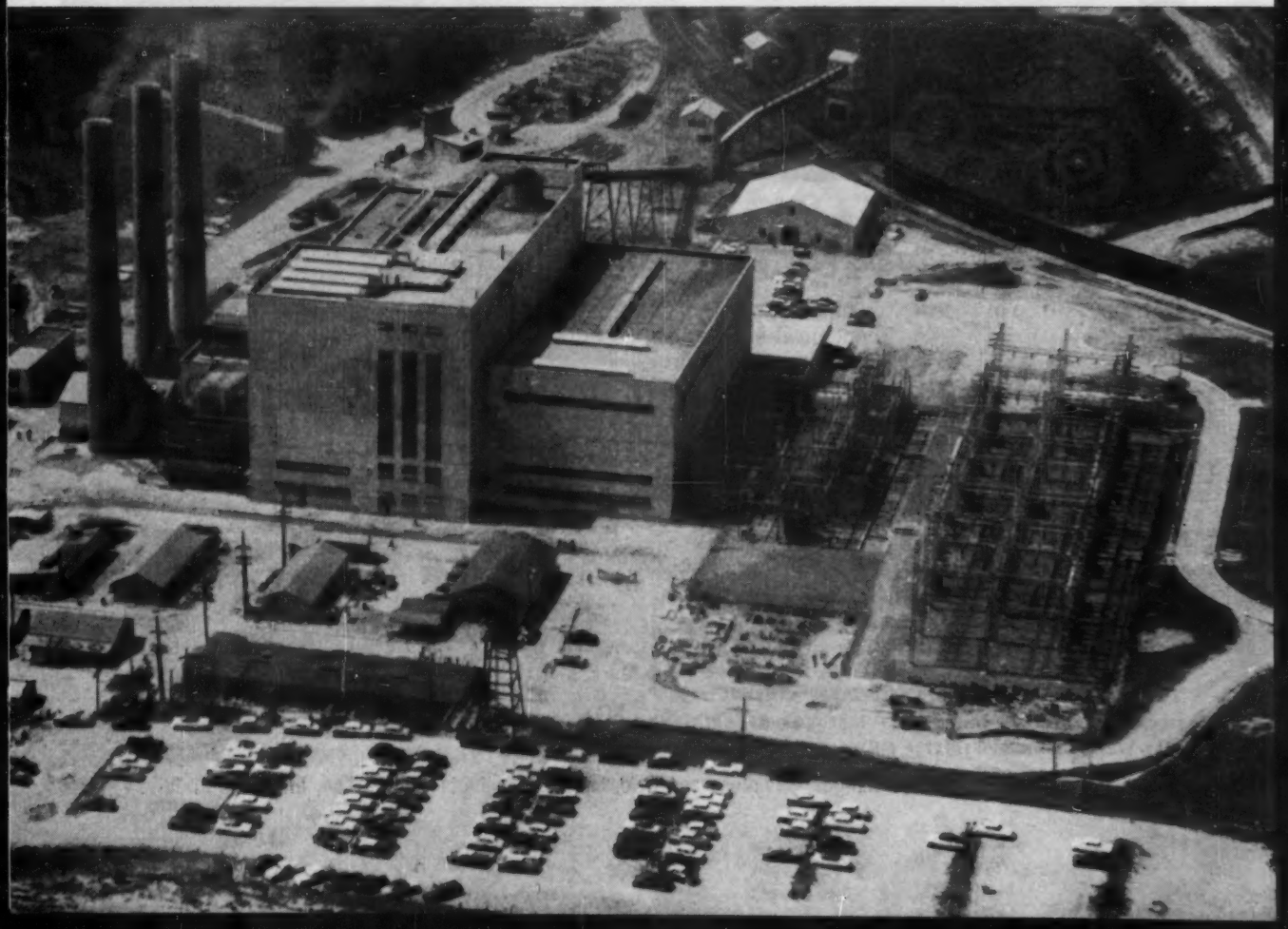
VEPCO, Stone & Webster and Combustion Engineering pioneered the power station application of this pump which was first developed to handle radioactive fluids in nuclear reactor loops. All the development work is now complete and the installation has been in actual service at Possum Point for over a year. J-57005-X



Westinghouse "canned" pump in Combustion Engineering controlled circulation boiler at Virginia Electric's Possum Point Station.

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU**!*



Fit-up is Fast, Easy and Permanent with B&W CROLOY Elbows

THIS end-use required welding fittings resistant to heat and corrosion—*plus* economical fabrication. B&W CROLOY 5 was chosen to meet service requirements. Dimensional accuracy and uniformly beveled ends of B&W Elbows simplified the welding procedure.

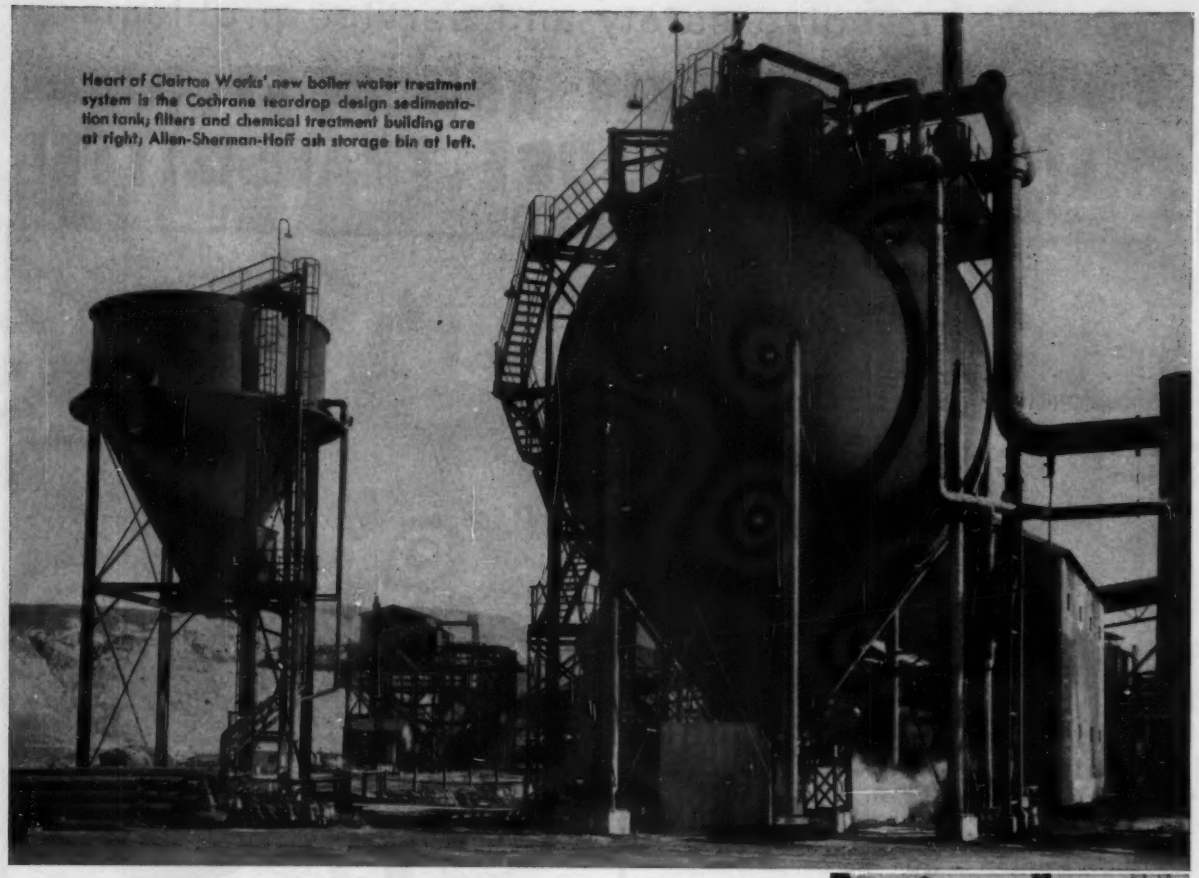
CROLOY 5 is one of a complete series of chromium molybdenum alloy steels developed by B&W to meet varying conditions of corrosion and oxidation in elevated pressure service. Further information on CROLOY 5 is available in B&W Bulletin 146.

B&W Alloy Welding Fittings and Flanges reduce fabricating time because they provide positive alignment at joints and are quick and easy to weld. B&W Bulletin 502 gives complete information.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION • FITTINGS DEPARTMENT
3839 WEST BURNHAM STREET • MILWAUKEE 46, WISCONSIN

FA-6916

Seamless welding fittings and flanges, seamless and welded tubular products—in carbon, alloy and stainless steels



Heart of Clairton Works' new boiler water treatment system is the Cochrane teardrop design sedimentation tank; filters and chemical treatment building are at right; Allen-Sherman-Hoff ash storage bin at left.

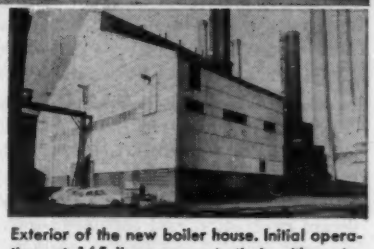
How U. S. Steel solved a construction-production problem at Clairton

For several years engineers at U. S. Steel Corporation's Clairton Works searched for ways to meet increased steam demands at their coke oven and benzol plants. Existing boilers were being pushed to capacity and production requirements were mounting so rapidly that the only logical solution was new boiler facilities . . . but such a project presented several formidable problems as production would have to be maintained during construction, and the expansion had to be confined to a limited area to allow future expansion.

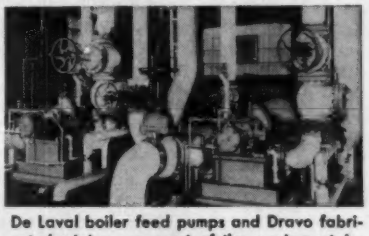
Solution to this problem is a good example of how Dravo's "complete package" construction service can work for you. After identifying their requirements and setting-up the necessary engineering specifications U. S. Steel engineers contacted Dravo for some preliminary estimates and construction ideas. What they received was a complete, coordinated plan for the whole program that relieved them of the multitude of planning details and permitted their dealing with one prime source of responsibility for the entire project.

Result was construction by Dravo of an expandable boiler plant and water treatment system to their requirements and without a day's loss of production time. The new plant is capable of supplying 200,000 lbs. of 600 degree steam per hour at 250 pounds pressure and treating 100,000 gallons of water per hour with a deaerating capacity of 80,000 lbs. per hour.

You, too, can profit through Dravo's single-contract responsibility, ranging over all types of jobs from boiler plant construction to the installation of a pump. Write for complete information.



Exterior of the new boiler house. Initial operation at 165 lbs. pressure to tie in with equipment in original boiler house, at right.



De Laval boiler feed pumps and Dravo fabricated piping are part of the equipment installed by Dravo.

Dravo Corporation, Department C-2112
Fifth & Liberty Avenues
Pittsburgh 22, Pa.

I am interested in Dravo Construction Services for_____

☐ Please send Bulletin #1200

DRAVO
CORPORATION
Pittsburgh 22, Pennsylvania
Representatives in principal cities

Name_____

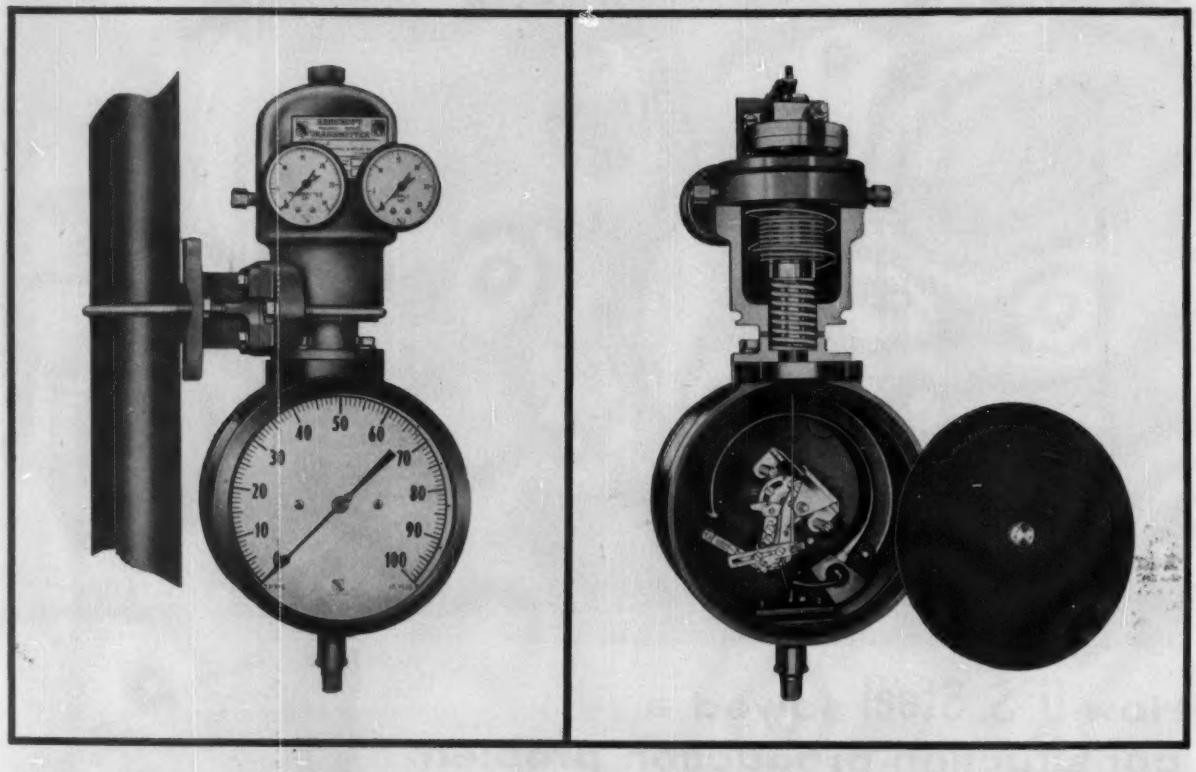
Company_____

Address_____

City_____ Zone_____ State_____

Designed to solve safety and service problems

...THE NEW ASHCROFT PNEUMATIC PRESSURE TRANSMITTER



This new Ashcroft Pneumatic Pressure Transmitter is particularly recommended to processing industries and power stations. It combines speed and accuracy with maximum protection and serviceability.

The new design features the 6" indicating Ashcroft Maxisafe Duragauge, long known for dependable performance. It has an integrally-cast solid metal wall between dial and pressure sensitive element so that the transmitter can measure pressures up to 100,000 psi with complete safety for personnel and equipment. If misapplication ruptures the Bourdon tube, the Teflon-coated back cover serves as a safety blowout relief.

Another outstanding design advantage is easy access to both gauge and transmitter sections. Simply remove the safety-relief back cover and both the gauge and transmitter can be calibrated. Yet a sealed housing makes the entire assembly weatherproof.

The transmitter operates on low-pressure air. No need for expensive high-pressure lines and fittings. Supply air pressure as low as 18-20 psi for 3 to 15 psi output provides especially advantageous operation where electrical wiring might be a hazard. Inflammable, poisonous or corrosive liquids or gases are confined close to their source, away from the central control point.

The Series 1250 Ashcroft Pneumatic Pressure Transmitter is available with pressure sensing elements in all standard pressure ranges and Bourdon tube materials. Installation of the transmitter is easy. Small diameter tubing may be used, and the pipe, stem, wall or flush mounts are interchangeable in the field. Get complete operational data and construction details. Write for Bulletin 340.

1850 ASHCROFT U.S.A.

YOUR INDUSTRIAL SUPPLY DISTRIBUTOR has the broad knowledge and thorough experience essential to satisfy every requirement of your Ashcroft Pneumatic Pressure Transmitter application. You get fast, economical service from his local stocks.

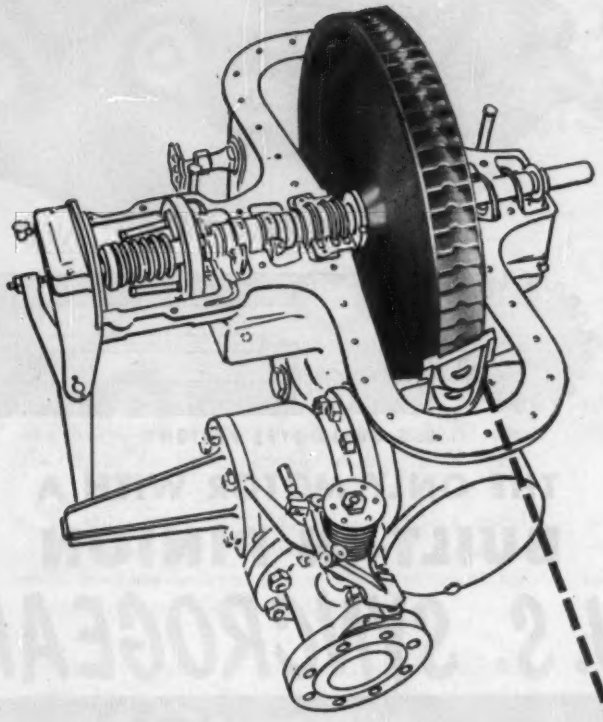
In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

ASHCROFT GAUGES

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS,' ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" and 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

Work Horse of Industry..since 1906



TERRY

1906 was the year this turbine was built in Terry's plant. It is believed to be one of the first small direct-connected turbines built for commercial use in the United States.

The Terry Steam Turbine Company was incorporated in 1906 to manufacture *a workable and efficient prime mover that would operate with minimum maintenance.* This prime mover was the solid-wheel turbine, which had been invented by Edward Clinton Terry a few years before.

Although maintenance practice has improved vastly since then, the demand for the turbine has multiplied many times. *Rising maintenance costs have actually increased the need for trouble-free operation.*

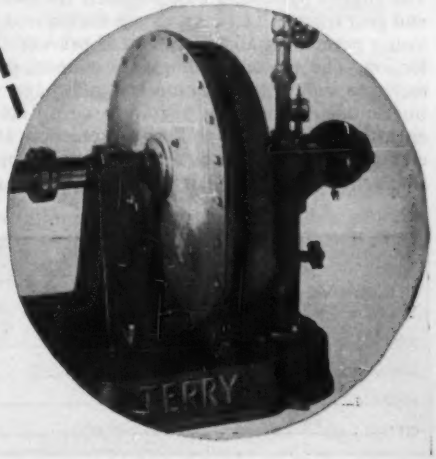
Today, there are more Terry solid-wheel turbines in operation, and there are more built each year, than ever before. The explanation is simple.

Here is a turbine with a virtually indestructible wheel. Made of a single forging of special composition steel, there are no separate parts to loosen or work out. As the only function of the blades is to form a series of pockets, any wear which may occur does not materially affect horsepower or efficiency.

Blades will not foul. They have large clearances and are further protected by the projecting rims at the sides of the wheel. As the side clearances are also very large, end play can do no harm.

These are a few of the reasons why the Terry solid wheel turbine has been the *work horse of industry – since 1906.* For the full story, send for a copy of Bulletin S-116.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

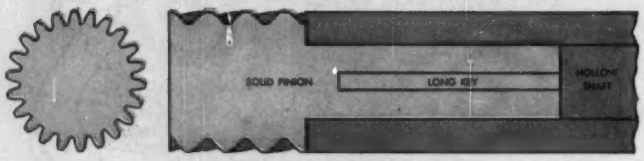


TT-1203

In your opinion, which pinion?

. . . for longest life in a gearmotor

ORDINARY SHELL TYPE PINION



U. S. SOLID TYPE PINION

In an internally geared motor the pinion on the motor shaft is the vital link between motor and gearing. It's the fastest, but smallest gear, so it must be extra strong, free from vibration and forever tight. Now compare the U. S. Syncrogear motor pinion with the ordinary type. Note the extra large section area of the U. S. design. It has a long solid shank that anchors into the motor's hollow shaft, whereas the ordinary shell type has a small section area, short keyed.

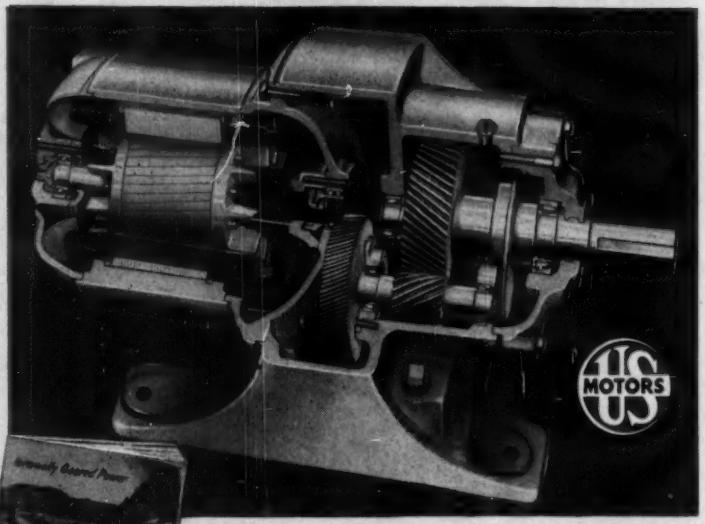
Obviously the U. S. design is most substantial, longer lasting, more resistant to deflection and can carry high speed loads far more safely than common designs. All the gears are deep-hardened and shaved to exact tolerances in the U. S. plants.

Added life lengthening features

The rugged pyramidal case supports the motor and gear train and all castings are normalized to insure permanent alignment and to prevent distortion. The motor windings are asbestos-protected to avoid carbonization and guard against burnouts. All moving parts are completely enclosed for weather and dust protection and confined within the least cubical dimensions on a single mounting. ¼ to 30 h.p.; 10 to 10,000 r.p.m.

THE ONLY MOTOR WITH A BUILT-IN PINION

U. S. SYNCROGEAR



FREE 16-PAGE DESCRIPTIVE BOOKLET GIVES ALL THE FACTS

Interesting multi-colored Booklet presents engineering facts you should know about geared motors, and illustrates the various U. S. Syncrogear types. Mail the Coupon for a copy. No obligation.

U. S. ELECTRICAL MOTORS Inc.

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LOUIS N ROWLEY, EDITOR • DECEMBER 1956 • ESTABLISHED 1882 **Power**

New frontiers in steam

WHEN I started my first power-field job, some 25 years ago, the Keenan steam tables had just appeared. Then, in 1936, came the Keenan and Keyes tables which have been, and still are, the "bible" for most engineers working with steam.

In introducing these tables, the authors noted that the range had been extended to 5500 psia and 1600 F. They believed this would be sufficient for a long time, and they were right.

But this business of ours never stops advancing and today we feel the need for working data beyond this range. We'll soon have steam generators operating at the extreme pressure limits of the Keenan and Keyes tables. And, because boiler-feed-pump work looms as a more important factor in cycle efficiency, we need more data in the low-temperature high-pressure region.

Completely authoritative figures on steam properties can only be developed by long and painstaking experimental activities. As part of an international program, the American Society of Mechanical Engineers is now directing and coordinating the four to six years of experimental work probably needed to develop accurate steam tables of greater range.

Wisely, I think, ASME has also taken steps to provide data that will serve for the period that must elapse until this experimental work can be completed. The result is an Interim Steam Table, covering the high-pressure region with data that is essentially correct, though subject to slight revision when experimental results become available.

This interim table has been developed by a subcommittee of the ASME Power Division. With the wholehearted assistance of many organizations and individual specialists they have provided a consistent and reasonable extrapolation of current tables, covering the range from 5500 to 10,000 psia, and 32 to 1600 F. Making use of existing data wherever possible, the subcommittee has adjusted values to join smoothly to the familiar and widely used Keenan and Keyes tables.

With this data, our equipment and plant designers can explore with confidence the higher steam conditions that promise the ever higher efficiencies we seek. And by the time we are ready to push into the region above 10,000 psia, the complete new tables should be at hand.

In just one generation we have gone from typical 1936 pressures in the 600-1500 psi range to extreme limits of the Keenan and Keyes tables. Knowing the dynamic nature of the power field and the ever more impelling economic need for better performance, does anyone dare now to venture a prediction as to how long it will take us to reach the 15,000 psia limit of the new tables?

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NORTHWESTERN GLASS CO.

"Our Production schedule was frequently disrupted by needless shutdowns on a line of motors . . *until we changed to Fusetron Fuses*"

James E. Davis,
CHIEF ELECTRICIAN, NORTHWESTERN GLASS COMPANY
SEATTLE, WASHINGTON

"Ordinary 500 amp. renewable fuses were blowing frequently in a 1000 amp. switch that controls a line of motors ranging in sizes up to 150 hp.

"We work on a tight production schedule, so these shutdowns with men and motors standing idle were costing us a considerable amount of money and trouble.

"As chief electrician, the problem was 'thrown in my lap'.

"A study of the situation indicated that harmless surges were causing the fuses to blow.

"We figured that the long time-lag of Fusetron dual-element fuses might correct the trouble.

"They were installed in 1953 and the original Fusetron fuses are still in service.

"We think this is quite a record because the switch is loaded to capacity 24 hours a day 7 days a week, only Christmas and July 4th excepted."

Here's why Fusetron Fuses give all purpose Protection

A fuse link combined with a thermal cutout - the result, a fuse with tremendous time-lag and much less electrical resistance and an interrupting rating in excess of 100,000 amps.

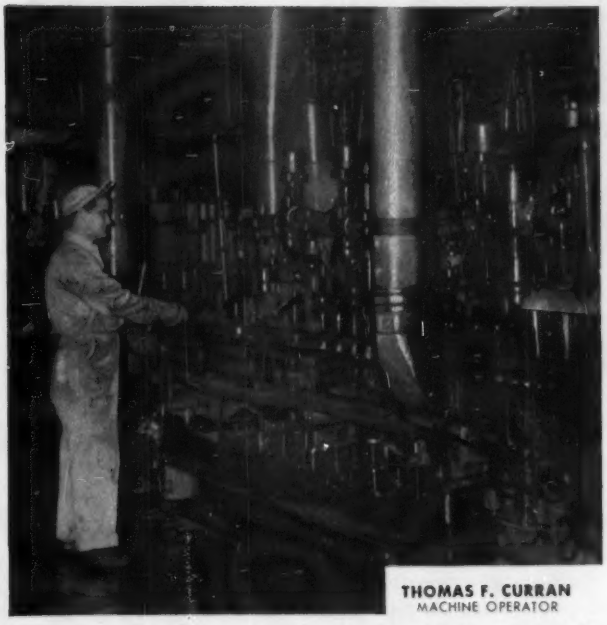
They have the same degree of Underwriters' Laboratories approval for both motor-running and circuit protection as the most expensive devices made.

Made to same dimensions as ordinary fuses. FUSETRON Fuses fit all standard fuse holders.

Obtainable in all sizes from 1/10 to 600 amperes, both 250 and 600 volt types. Also in plug types for 125 volt circuits.

Their cost is surprisingly low.

Write for bulletin FIS.



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They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuit of origin.

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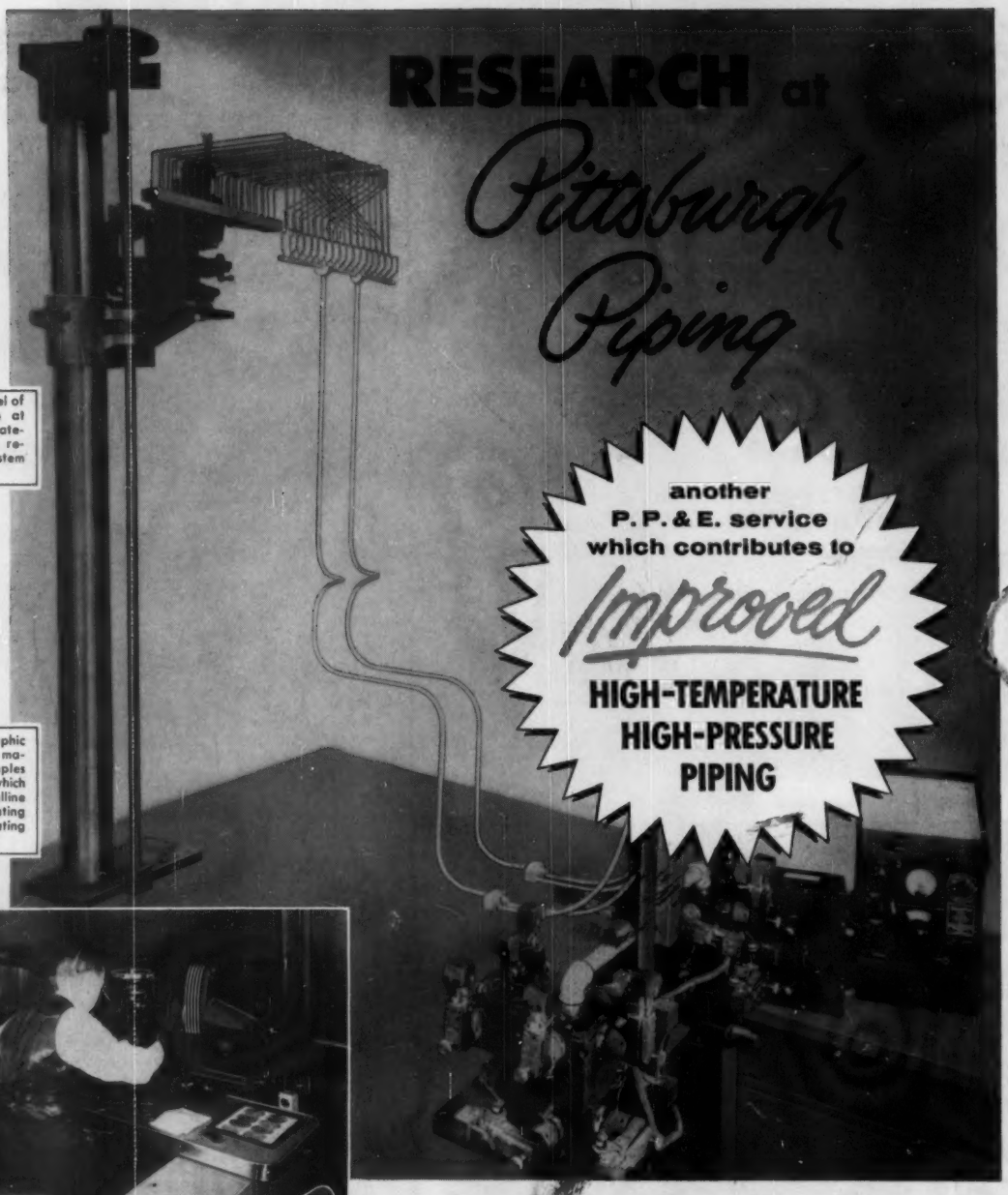
RESEARCH at Pittsburgh Piping



Stress analysis of model of power piping system at Pittsburgh Piping accurately predicts physical reactions of full size system in service.

another
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which contributes to
Improved
HIGH-TEMPERATURE
HIGH-PRESSURE
PIPING

(Below) Metallographic examination of piping materials and weld samples reveals changes which occur in a metal's crystalline structure due to operating conditions and fabricating procedures.

(Above) Fabricated sections comprising 20" pipe and elbows shop fabricated at Pittsburgh Piping.

Our technical staff constantly explores the mechanical and metallurgical aspects of power and process piping. For example, stress analysis by model testing is used to predict accurately the physical reactions of high-temperature, high-pressure piping in service. Extensive investigations are conducted on the metallurgical effects of operating conditions and fabricating procedures on piping materials. This knowledge pays off in the sound piping systems we fabricate and erect for central stations and nuclear power installations.

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CORROSION

By HOWARD P KALLEN, Associate Editor

Look at your plant through the eyes of a corrosion engineer and — if you don't now have a corrosion-control program — chances are you'd come up with enough corrosion-cost-cutting ideas to pay for your efforts many times over.

In coming to grips with the problem you'd tap know-how from many quarters — metallurgy, chemistry, electrical engineering, even geology and meteorology (in studying soils and weather effects on corrosion). Some of the weapons you'd use have been around for years. But you'd probably consider many of these newer ones too:

Latest corrosion-resistant metals, although they generally cost more to begin with, soon pay for themselves by standing up against corrosive waters, high temperatures, chemical attack.

Inert barriers, many of them today's newest synthetics — silicones, epoxies, vinyls — bring corrosion to a dead stop by setting up an impregnable wall around less corrosion-resistant materials.

Recent developments in the water-treatment field — more efficient deaeration, new inhibitors — promise more effective corrosion control in water systems.

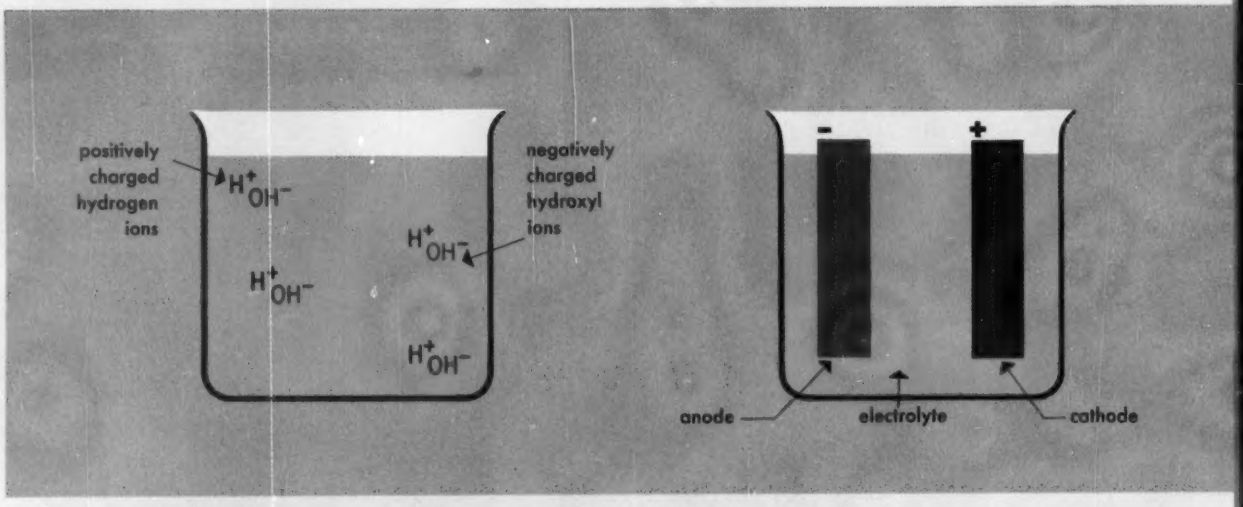
And cathodic protection—though its principles date back to experiments by Sir Humphry Davy in 1824 — has achieved wide usefulness only within recent years.

Why so much emphasis on corrosion now? At least part of the answer lies in the economics. Material and manpower costs continue to climb. Industry's annual bill for corrosion — at last count, pegged at roughly six billion dollars — follows the trend closely. Result: Corrosion-control programs offer an area fertile in cost-cutting opportunities.

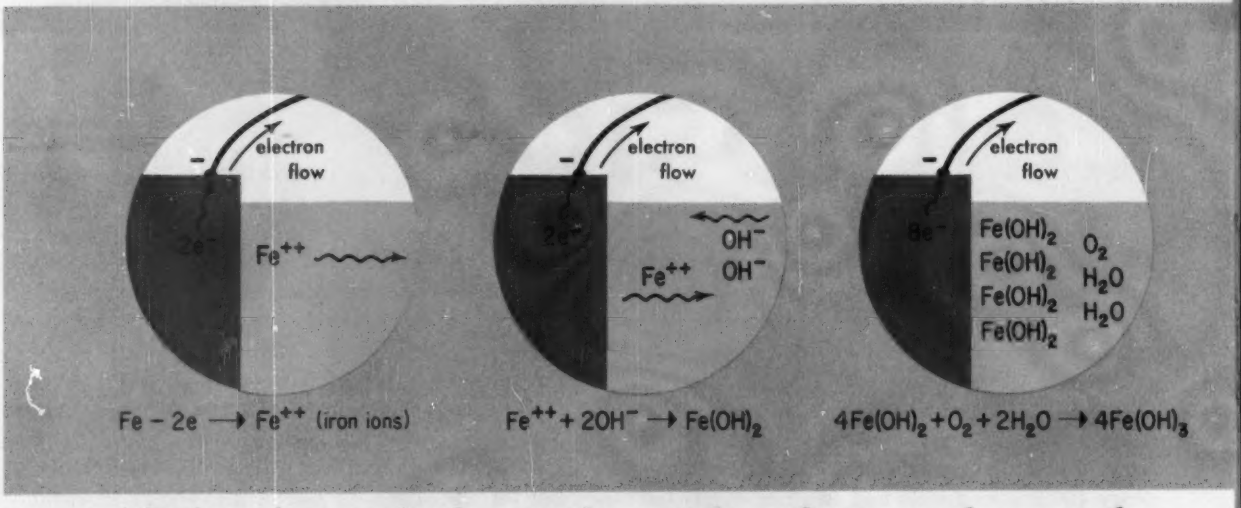
Engineering-wise, today's higher temperatures, pressures and tougher corrosive environments in general, make more exacting corrosion control a must.

Thus, we view corrosion as both an engineering and economic problem in this report. It leads off with basics, follows up with anti-corrosion weapons, practical applications, corrosion testing and programs. Let it guide you in bringing the latest thinking to bear on the corrosion problems of your plant.

Corrosion – nature's wasteful way



The electrolyte couples anode and cathode areas to form



Oxidation (corrosion) reactions take place at the anode,

Corrosion is simply nature's way of trying to revert refined metals to their natural state. Take iron for example. When iron corrodes it forms rust. Analyze rust and you'll find it's iron oxide. Iron ore, too, is iron oxide. Thus, we can picture corrosion as an attempt to undo man's "meddling" with the metallic ores found in nature.

Corrosion basically is an electrochemical action, much like that in an electric dry cell. Electricity flows between metal areas through a solution. Deterioration (corrosion) takes place where the current leaves the metal and enters the solution. This area is called the *anode*.

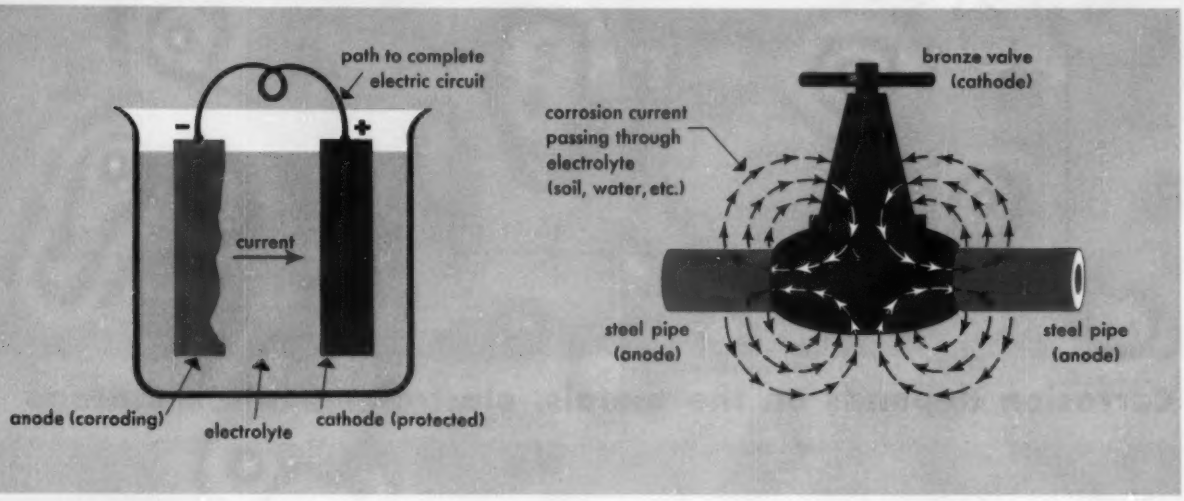
Electrolyte—the conducting solution—may be water, soil, chemical solutions, etc., depending on the application.

Cathode is the area at which current returns to the metal. The electrodes (anode and cathode) may be two different metals or different areas of the same metal. In both cases we find a difference of potential (voltage) between the two electrodes, causing current to flow between them, just as a dry cell causes flow in the common electric circuit.

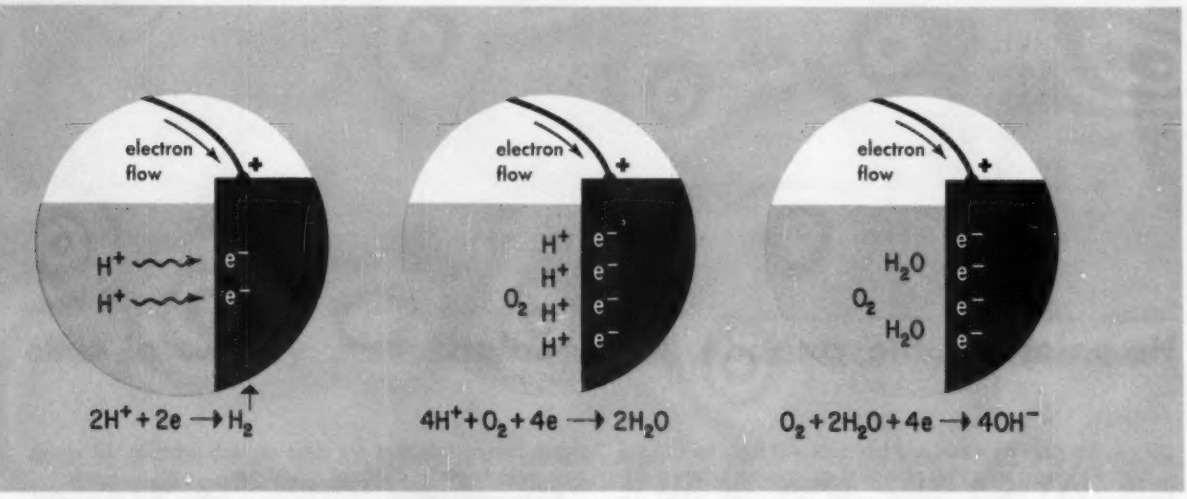
Electron path. Besides the electrodes and electrolyte we also need a path to complete the electric circuit. In actual corrosion, the metal structure itself may provide the path. Or the circuit may be completed by physical contact between the metals.

Electron flow results from a difference in potential between two points in a circuit. When corrosion occurs, electrons (negative charges, e^-) leave the anode and flow to the cathode along the path between the two. The electrons are released by metal atoms at the anode surface. When an electron leaves an atom, the atom becomes positively charged because it has a deficiency of negatively charged electrons. The atom is then a positively charged *ion*.

# of returning metals to their ores



a galvanic cell. **It may look like this in your plant**



while reduction (protective) reactions go on at the cathode

The electrolyte also contains ions. Pure water, for instance, contains equal numbers of positively charged hydrogen ions (H^+) and negatively charged hydroxyl ions (OH^-). These ions play an important role in corrosion. Let's see how.

During corrosion of iron in water, each iron atom releases two electrons as it becomes ionized. The electrons flow in the circuit path to the cathode. Iron ions form at the anode, are attracted by negatively charged hydroxyl ions in the electrolyte and pass into solution. Electrons arriving at the cathode neutralize some of the hydrogen ions that have collected there. As the process continues, hydroxyl ions left behind attract more iron ions into solution, forming the unstable compound ferrous hydroxide, $Fe(OH)_2$.

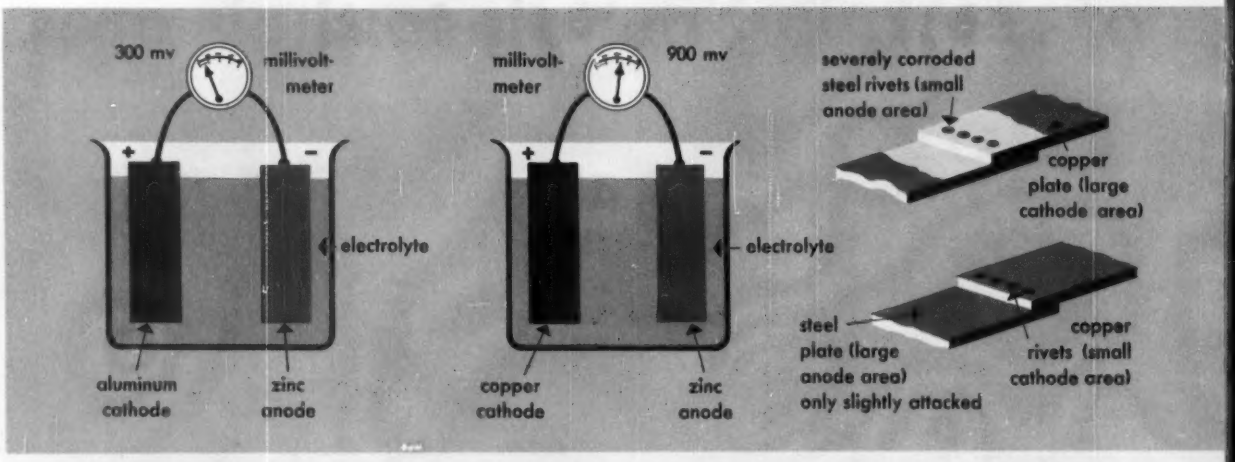
Final step in corrosion of iron is the oxidation of unstable ferrous hydroxide. It combines with oxygen in the electrolyte to form ferric hydroxide, $Fe(OH)_3$—common rust.

Remember: Anode and cathode processes can't occur separately. One supports the other. But corrosion itself takes place at the anodic areas.

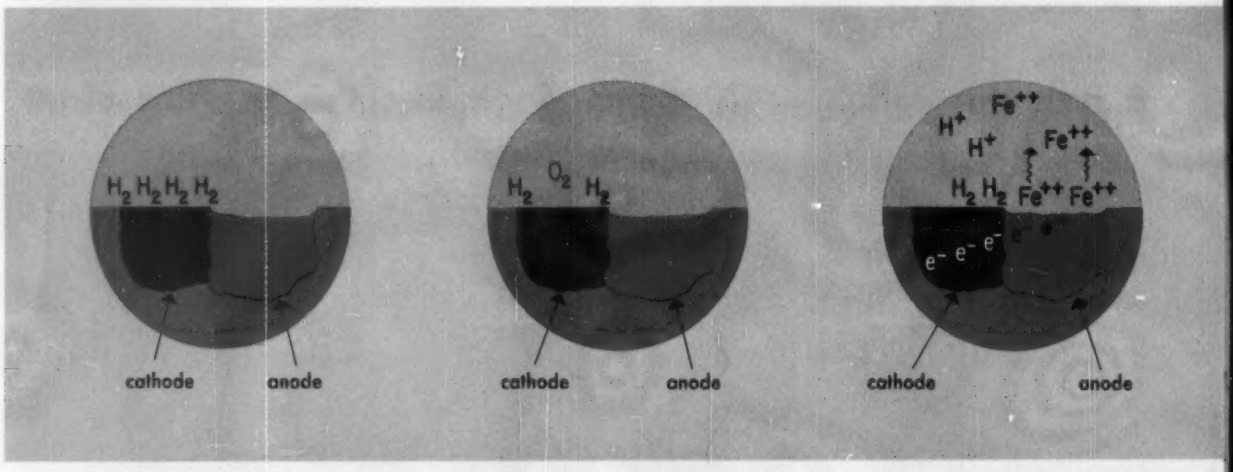
Rust may break away from the metal surface or remain there to influence the progress of corrosion. Alkalinity, oxygen content and agitation of the electrolyte all come into

A word about sign conventions

Positive and negative sign conventions used here are opposite those electrical engineers use because the U.S. Bureau of Standards calls platinum (the cathode) positive to magnesium (the anode). To avoid confusion remember: Cathode is the protected member; anode corrodes.



Corrosion depends on the metals, electrolyte, relative areas



H_2 polarizes the cathode, O_2 depolarizes it. Local cells

play in determining where and how rust will form on a metal.

We've already seen that potential differences between different metals, or from point to point on a single metal, are a necessary condition of corrosion. The action between different metals is called galvanic because they form a galvanic couple (two metals). Corrosion currents flowing between two points on the same metal surface are *local*. But whether the current is due to local or galvanic action, we'll need to understand how it originates before we can bring the right preventive measures into play.

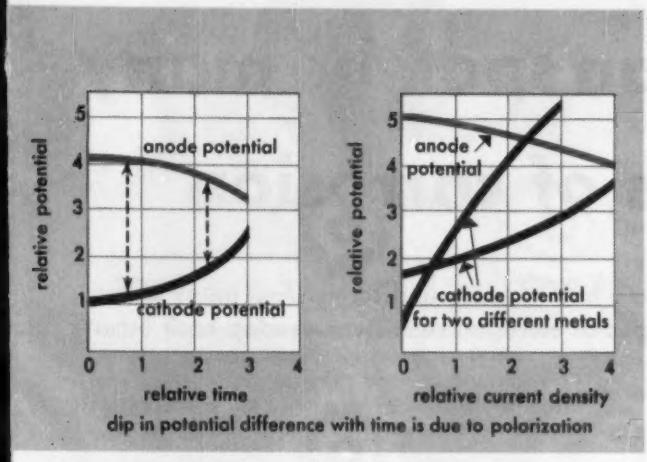
In dealing with galvanic corrosion it's essential to know which metal in the couple will corrode (act as the anode). The galvanic series of metals and alloys, *facing page*, can supply a quick answer. Metals near the top of this series are anodic with respect to metals below them. And metals grouped close together have less tendency to produce a galvanic couple than metals from widely separated groups. Thus, zinc shows strong anodic characteristics when coupled with copper. Tin and lead, on the other hand, have little galvanic effect on each other.

In using any galvanic series you'll need to exercise caution. These series may vary somewhat, depending on the corrosive environment (electrolyte). And the potential between two metals that are close to each other in the series, may reverse under different conditions.

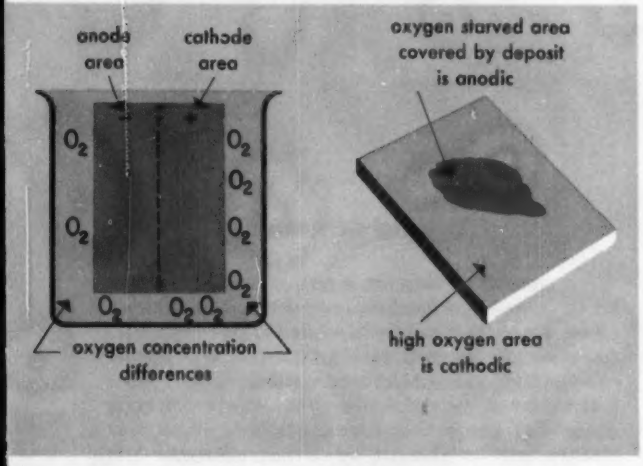
Stainless steels are listed twice, as active and as passive. Under certain conditions, they'll act cathodically even with respect to copper. But put them in a different environment and they're only slightly more passive than ordinary iron and steel. We'll have more to say about this later under inhibitors and passivation.

Corrosion rate. How fast do anode metals corrode? What controls corrosion rate? Right answers to these questions often spell the difference between good and poor corrosion control. Again, we find at least part of the answer by looking at the galvanic series. Coupling widely separated metals in the series yields relatively greater galvanic potentials. Driving force behind galvanic corrosion is roughly proportional to these potentials. Differences as little as 0.1 volt indicate substantial galvanic action. Thus, we usually make measurements with a sensitive millivoltmeter.

Polarization. As corrosion products build up at anode and cathode, the voltage differences tend to dip. Anode and cathode voltages drift toward each other, slowing down corrosion rate. This voltage change is called *polarization*. Polarizing at the cathode is usually greater than at the



as well as polarization



Galvanic Series

Anodic, corroded end	Muntz metal
Magnesium	Brasses
Magnesium alloys	Copper
Zinc	Bronzes
Aluminum	Copper-Nickel alloys
Cadmium	Nickel
Mild steels	Inconel
Alloy steels	Stainless steels (passive)
Wrought iron	Hastelloy C
Cast iron	Titanium
Stainless steels (active)	Silver
Ni-Resist	Graphite
Soft solders	Gold
Lead	Platinum
Tin	Cathodic, protected end

Metals near the top of this series act as anodes, suffer corrosion when coupled with one nearer the bottom. Galvanic couples of metals close together in this series usually corrode more slowly than couples composed of metals from the extremes.

Note too that certain metals are grouped together. Couples of metals within these groups have the least tendency to corrode.

are set up by metal-ion and O_2 concentration differences

anode. So we're more likely to be concerned with its cathodic effects. Hydrogen gas, for instance, can blanket the cathode surface, cutting corrosion at the anode. But hydrogen may soon be removed by combining with oxygen to form water.

Some metals polarize easier than others. So it's important to know the metal's polarizing tendency as well as its initial potential.

Relative size of anode and cathode also affect polarization. Here's why: Drifting potential at the cathode depends not only on current but on *current density*. For the same current flow, current density is greater on a small electrode than on a big one. Also, as hydrogen ions reach a large cathode they are spread relatively thin. Thus they can combine more readily with oxygen, retarding polarization. In brief, relatively small cathodes promote high current density, retard the action of oxygen as a cathodic depolarizer. We're flirting with corrosion when we couple large cathodes with small anodes.

Local corrosion. Potential differences between areas on the same metal cause local corrosion currents. They often result from variations in the conditions of the air, soil, water, etc., next to different sections of the metal. For example, we find different metal-ion concentrations where relative speeds of electrolyte over the metal are greater at one point than another. Metal ions accumulate where speeds are lower, become cathode areas. Anodes form where relative movement is high, causing these areas to corrode.

If we rotate a metal disk at high speed in water, we find that it tends to corrode near the edge where linear velocities are highest. Speed sweeps away metal ions, forming anode areas. But by choosing an alloy to suit velocity conditions, the effect of low metal-ion concentration can be avoided.

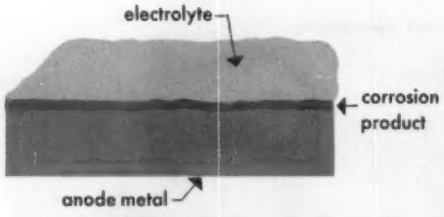
Oxygen concentration cells can also cause local corrosion. Surprisingly enough, high-oxygen-concentration areas form cathodes. And we can measure the corrosion current flow between points of differing oxygen density.

Common condition causing oxygen-cell attack is the presence of a deposit at one area of an otherwise freely exposed metal. A small sand hill on a clean brass surface attacks brass under the sand. Electrons flow through the metal to the surface outside the sand. Result is the *reduction* of oxygen in the exposed area (the cathode).

Note that in all corrosion cells, whether they're local or galvanic, reduction reactions take place at the cathode (protected area); oxidation reactions at the anode (corroding area). One chemical reaction supports the other.

Here's how you can spot the many common varieties of corrosion

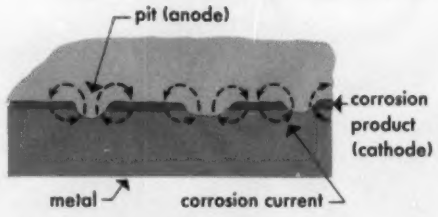
It can show up in a host of ways and forms. And many of the most common types of corrosion conditions overlap each other



Uniform attack

Look for a general wasting away of the surface. You'll find this condition all too common where metals are in contact with acids, other solutions. But the presence of a solution isn't always essential. High-temperature oxidation, for instance, is a form of uniform attack that can take place in a relatively dry atmosphere.

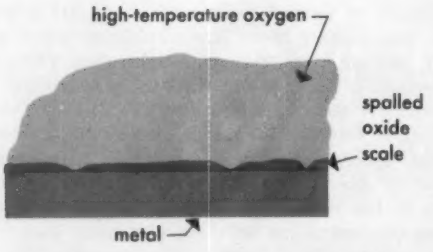
The corrosion product may form a protective layer on the metal, slowing down corrosion. Or, as in the case of direct chemical attack, the corroded material easily dissolves in the corrosive material.



Pitting corrosion

When protective films or layers of corrosion product break down we get localized corrosion—pitting. An anode forms where the film breaks, while the unbroken film or corrosion product acts as the cathode. Thus we've, in effect, set up a closed electrical circuit.

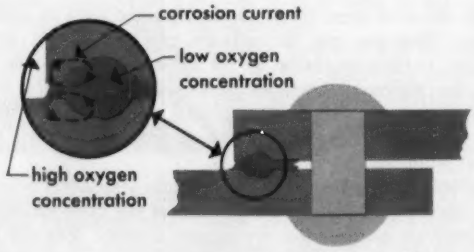
Corrosion pits take a heavy toll in machinery and equipment because they concentrate their attack over a small area. Pits also act as starting points for stress concentrations that spell trouble, especially where pits line up in rows that can become major breaks.



High-temperature corrosion

To predict the effect of high-temperature oxidation we need data on: (1) metal composition (2) atmosphere composition (3) temperature, and (4) exposure time. So it's not easy to tell what will happen in one case, from the results of another. But we do know that most light metals (those lighter than their oxides) form a nonprotective oxide layer that gets thicker as time goes on. The layer forms, spalls and reforms.

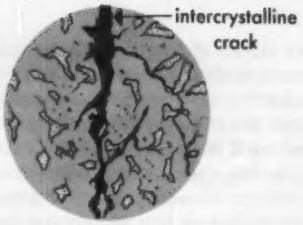
Other forms of high-temperature corrosion include sulfidation, carburization and decarburization.



Concentration cells

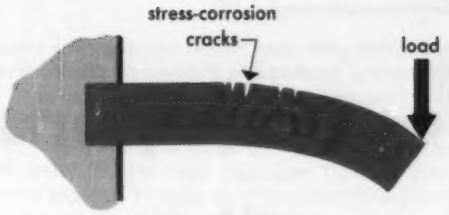
You'll recognize this condition by its presence in crevices. It sets up differences in solution concentration. The crevice, above, for example, hinders diffusion of oxygen. Result: High and low oxygen areas that cause concentration cells. Low oxygen area is anodic.

Metal-ion concentration cells, much like their oxygen counterparts, also strive to balance out concentration differences. Thus, when the solution over a metal contains more metal ions at one point than another, metal goes into solution where ion cencentration is low.



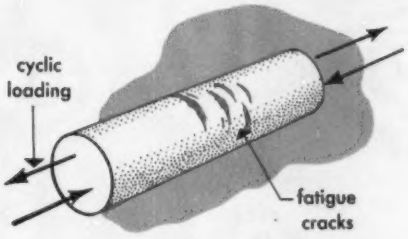
Intergranular corrosion

You may be faced with intergranular corrosion for a variety of reasons. But the result is almost always the same — selective attack along the metal's grain boundaries—intercrystalline cracking, such as we picture in the photomicrograph above. In some austenitic stainless steels, chromium carbides may precipitate at grain boundaries when cooling from welding temperatures. Corrosion is free to attack chrome-starved areas.



Stress corrosion cracking

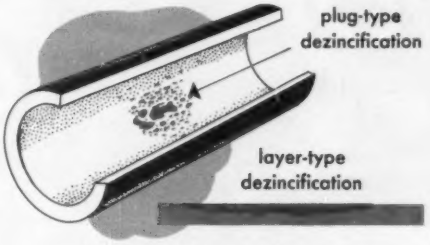
Team up high tensile stresses with a corrosive atmosphere and you're likely to be in for trouble. Here's how it develops. Tensile stresses build up at metal surface under static loading. Corrosive action concentrates stresses, causes them to exceed metal's yield point. Result shows up as a local failure. Under continued exposure, metal alternately corrodes, builds up high stress concentrations. Eventually the part may fail.



Corrosion fatigue

In much the same way that static stresses link up with corrosion to produce stress-corrosion cracking, cyclic loads work hand-in-hand with corrosion to cause corrosion fatigue. Metal failure takes place substantially below the fatigue limit for non-corrosive conditions.

Surprisingly enough, the combined deteriorating effect of these two bed brothers — corrosion and fatigue — is greater than the sum of their individual damages. So it pays to apply best possible corrosion protection when dealing with metals under alternating stresses.

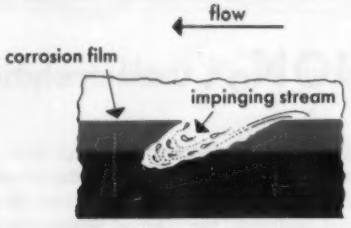


Selective attack

Basically, one element of a metal or alloy is singled out for corrosive attack. Common types are dezincification and graphitic corrosion.

When we expose copper-zinc alloys (brasses) containing less than 85% copper to wet conditions for prolonged periods, zinc may be lost from brass. Resulting porous zinc-free mass of copper has little mechanical strength.

Common cast iron can act this way too. In some corrosives, iron corrodes out, leaving nothing more than a porous graphite residue that virtually crumbles.

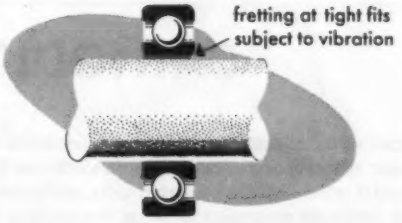


Impingement attack

Similar in their method of attack and net effects are impingement corrosion and cavitation corrosion. Here's how they do their damage:

An impinging water stream breaks through corrosion scale, dissolving the metal. Effect depends mainly on liquid speed.

Cavitation, a common form of corrosion in pumps, depends on the hammer-like effect produced by collapsing air bubbles. Bubbles break down when they pass from a low-pressure to a high-pressure area.



Fretting corrosion

Picture the ball bearing above supporting a heavily loaded high-speed shaft. Its inner race is press fit on the shaft. If high-frequency vibrations produce even minute slippage between these surfaces, local attack may start fatigue cracks, especially where stresses concentrate. Take shaft and bearing apart. You'll find their mating areas pitted.

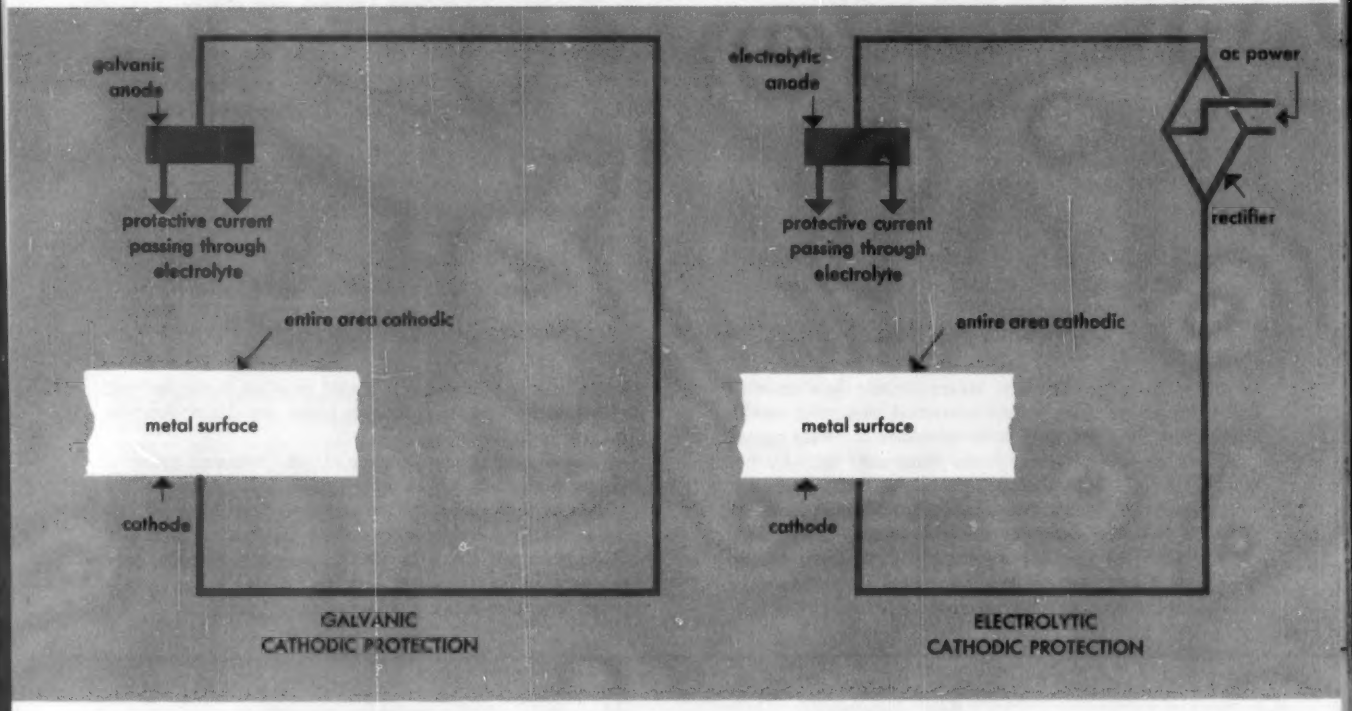
Likely explanation for fretting: Slippage shears away surface-protective films, laying bare the undersurface to galvanic attack and concentration-cell corrosion.

Your weapons in the endless war on corrosion

So far we've talked almost exclusively about fundamentals – electrochemical theory, basic corrosion types, etc. In the next 14 pages we turn to the more practical elements of the problem – weapons for the fight against corrosion.

Weapons we'll consider include cathodic protection, engineering metals (ferrous and nonferrous), inert barriers (organic, metallic, vitreous), ways of altering the corrosive environment, inhibitors and temporary protection.

Not all these techniques will apply in your plant. Perhaps your corrosion problem can only be handled by changing the corrosive environment. But in any case, it'll pay you to know *all* the tools available. Remember: Your future machinery and equipment may not fit your present corrosion-control methods.



CATHODIC PROTECTION . . . electrolytic and

The great value of cathodic protection lies in its simplicity and direct effectiveness. To see how it works we'll make use of a modification of the galvanic cells we've viewed thus far: The cathodic protection battery. It's nothing more than our original galvanic cell with an auxiliary anode acting as a substitute for the anode on the metal surface we want to protect.

Auxiliary anodes may be either electrolytic (energized by an external source of direct current) or galvanic (made up of a metal higher in the galvanic series than the metal to be protected). In either case, the electrical energy supplied by the auxiliary anodes forms a *fence* that prevents current flow in the local cells on the protected surface. With current flow stopped, metallic ions can't escape from the area we want to protect.

In our original galvanic cell, anodes on the metal surface released metallic ions, causing the metal to corrode. The cathodic protection battery transfers the corrosion process to the auxiliary anodes. These anodes are eventually consumed in protecting our metal structures. But anodes can be replaced. In brief, the method is fighting corrosion with corrosion – protecting one metal at the expense of another.

Most common applications of cathodic protection are for submerged (in soils, liquids) metal surfaces but the same principles apply to the protection of metal in any electrolyte.

Current density. A must in planning any cathodic protection system is finding the current density needed to maintain the electrical *fence* at all areas to be protected. Right current density is essential because the potential of the area to be protected doesn't reverse itself (become cathodic) until the protective current density is reached.

Protective current density depends on many factors that

Economics. A major question you'll face in the endless battle against corrosion is deciding how much protection is economically justified. To come up with an intelligent solution, you'll have to consult plant production people to get answers to questions like: How long will the equipment be used before it is obsoleted by more modern machines? Is equipment operated continuously or intermittently? How high is the operating temperature? Is the machine indispensable to the over-all process? What are the probable corrosives involved? You'll have to weigh all factors — tangible and intangible — in any complete economic study.

Your corrosion-fighting arsenal can include many of today's newest methods too. Researchers are taking giant steps in their attempts to upgrade these methods.

Protective coatings and paints have been radically improved with the development of new vehicles and inhibitive primers. These assure better protection on the job.

Newer corrosion-resistant metals and alloys can, if you apply them right, stand up under severe corrosion conditions. Naturally, they're more expensive than the less-resistant materials they replace. But their increased life span can more than pay for initial cost differences.

Plastics, relative newcomers to the battle against corrosion, are widely used, both structurally and as coatings.

Cathodic protection, still another approach to your corrosion problem, is daily proving itself a top protective weapon for pipelines, power cables, condensers, storage tanks and a host of other industrial equipment.

Choosing the right anode—key to good cathodic protection

Once we've decided on needed current density, next step is to choose the right anodes and arrange them to distribute current to *all* parts of the structure in contact with the liquid or soil. To do the job we can use electrolytic or galvanic anodes, *diagram facing page,* or a combination of the two. In either case, right anode position, quantity, length and area in relation to the protected surface, play an important role in planning the system.

Electrolytic Anodes

Electrolytic anodes can be expendable or non-sacrificial — both energized by an external dc source. Expendable types include iron, carbon steel, chrome steel, aluminum and graphite. Non-sacrificial designs are made of platinum.

High-silicon cast-iron anodes, either bare or installed with backfill, are a recent development for ground-bed (soil) installations. They resist sulfated, alkaline and most chloride-containing soils. Their best performance is at 5 amps per sq ft, and below. But even if you're faced with substantially heavier currents, anode weight loss is slow, predictable.

Platinum may be used in the form of a small diameter wire, or by cladding a copper or nickel rod. For protection of submerged surfaces, platinum anodes are expensive. Thus, their use is limited. Also, the economically justifiable diameter of platinum anodes often produces a large voltage drop, high power costs.

Graphite anodes can last for many years. So it's smart to consider them in areas where replacement is a difficult and costly process. If you're installing them in soil, manufacturers recommend a granular coke breeze backfill to allow gas formed to disengage itself from the graphite anode.

Galvanic Anodes

Galvanic anodes are made of a metal higher in the galvanic series than the metal you're trying to protect. That's why they require no outside current source. They're always sacrificial. Common materials are zinc, magnesium, aluminum.

High-purity zinc, aluminum alloys do a top job in sea water. Zinc is also used for lower resistivity soils (less than about 2000 ohms per cc). Magnesium works well up to 10,000.

Relatively low driving voltages generated by galvanic anodes can be an important point in their favor. Below city streets, for instance, they're less likely to interfere electrically with nearby structures. But low voltage may limit their use where current requirements are high.

galvanic methods fight corrosion with corrosion

vary considerably. And you can't assume that any two jobs will be exactly alike. The most important items affecting protective current density are type and condition of applied surface coating (if any), dissolved oxygen concentration, chemical analysis of the electrolyte, as well as its conductance, temperature and pH.

Water conditions. A 2 to 4 milliamp (ma) per sq ft current density is enough to protect a bare steel surface. This is easy to maintain in waters of average hardness. Soft water, because of the absence of dissolved salts, tends to be more electrically resistant and requires higher voltages, more anodes to produce a protective-level current. Hard water has low resistance. And if system isn't designed to operate at lowest voltage consistent with adequate protection, high current quickly consumes anodes.

Coatings teamed with cathodic protection can often prove most economical. Then only small areas, where faults or pinholes exist, need protection. These areas demand only a small current, radically reducing auxiliary-anode consumption.

Type of protection, as we've seen, can be either electrolytic or galvanic. Electrolytic protection — the impressed-current method—is commonly used where relatively large amounts of current are needed at a few locations. Galvanic techniques work best where we need to apply smaller currents at many locations. Notice that in both cases we're dealing with direct current (dc).

Choosing the right equipment to get the necessary power can be of prime importance. Several types of power units are available. Motor-generators, wind generators and rectifiers that convert ac to dc, are applied on electrolytic systems. Galvanic action itself supplies power for the galvanic system. To pick the right one you'll have to weigh their economic as well as technical merits.

Cast iron, carbon steel

Relatively cheap, easy to come by, cast iron and carbon steel lead the engineering-metals field in total volume and applications – many of them corrosive.

Cast iron contains 3 to 3.5% carbon, along with silicon and other elements. Structurally it includes iron, iron carbide and free carbon (graphite).

Corrosion resistance of cast iron and carbon steel are about the same. But there are exceptions, and a look at their relative structures tells why: Carbon in carbon steel is present as iron carbide, whereas some carbon in cast iron is free graphite. Thus, gray cast iron is subject to graphitic corrosion (see page 79) in salt and mine waters and sulfate-containing soils. White cast iron is immune to such attack because nearly all its carbon is in the carbide form.

Metallurgists find that while carbon in steel has an important effect on its physical properties, it has little effect on corrosion resistance.

Wrought iron

We single out wrought iron because, under certain conditions, it provides an economical solution to corrosion problems. Briefly, wrought iron is a two-component metal consisting of high-purity iron and iron silicate – a glass-like slag. It's the only ferrous metal that contains such a slag. The iron silicate is largely responsible for wrought iron's corrosion resistance.

Unlike either steel or cast iron, wrought iron is never cast in an ingot mold. So its structure and composition don't change near the surface. Uniformity minimizes chances of accelerated corrosion rates after material has been in service for several years.

High-silicon irons

Ideal for corrosive conditions involving high temperature and erosion attack, these cast irons are relatively low cost. Their main alloying element is silicon – 14.5%. They also include .85% carbon, varying amounts of manganese and molybdenum.

Although high-silicon cast irons have fair tensile strength, in common with all cast irons they have no ductility. And they're prone to thermal, mechanical shock. Thus, steam tracers are commonly used with high-silicon irons to avoid too-rapid heating and cooling. When used in this way, these irons can operate in systems at as high as 1000 F without difficulty.

Cast high alloys

Two main classes of cast high alloys are iron-chromium and iron-chromium-nickel.

The iron-chromium alloys having between 8 and 14% chromium have the characteristics of steel. They can be altered by heat treatment. Higher chrome and chrome-nickel content alloys don't show the phase changes that steel does when it's heated or cooled. Thus, they're non-hardenable. Their properties depend on composition rather than heat treatment.

Many of these alloys are used for corrosion- as well as heat-resistance. But heat-resistant types usually contain more carbon.

Corrosion resistance of equivalent wrought and cast alloy compositions are just about equal.

Copper-bearing steels

Adding small amounts of copper to steel, can boost its corrosion resistance substantially – especially where corrosion is due to atmospheric conditions. But adding copper to steel for underwater, soil applications, usually has little effect on corrosion properties.

Adding phosphorus to copper-bearing steels shows good results too. For example, one test showed that increasing phosphorus from 0.005 to 0.070% in a 0.5% copper steel increased corrosion resistance in an industrial atmosphere about 25%.

MODERN ENGINEERING METALS . . . weigh them

The array of metals that appears on this and the following three pages includes virtually all of the major engineering types, with these exceptions: (1) the noble metals – silver, gold, platinum (2) metals that are used mainly as alloying elements – tungsten, vanadium, molybdenum, manganese, chromium. But we mention them above, where they're added to base metals, as alloying elements, largely to improve corrosion-resisting and mechanical properties.

Choosing the right metal. In coming to grips with this problem, the engineer usually has little difficulty eliminating those metals which just won't do. His big problem is evaluating the finer differences that exist among the closest candidates. And often, the corrosion problem becomes the deciding factor. Other times it takes equal importance alongside such items as: (1) availability in the required forms – castings, sheet, tubes, forgings, etc. (2) ease of fabrication – machining, forging, bending, welding (3) ability to stand up under normal service stresses.

Focusing now on the corrosion factors themselves, let's see what we must consider in selecting the right engineering metal for specific applications.

Low-alloy steels

One definition of low-alloy steels: Total alloy content is 5% max. Generally speaking, metallurgists add these elements to boost strength and toughness, rather than corrosion resistance. But corrosion resistance of most low-alloy steels is generally better than carbon steels. Anticorrosion standouts are the low-chrome heat-resisting steels commonly used for superheater tubing in boilers. These include 2%-chrome ½%-molybdenum; 2¼%-chrome 1%-molybdenum; 3%-chrome 0.9%-molybdenum. They're selected for their heat- and corrosion-resistant properties.

9%-chrome 1%-molybdenum superheater steel contains too much alloy to be called a low-alloy steel but not enough chrome to be considered in the stainless class. It's basically an intermediate alloy steel. Corrosion resistance of these low and intermediate alloy steels falls between the copper-bearing and stainless steels commonly used by industry.

Austenitic stainless

Corrosion and oxidation resistance of all stainless is based on chromium. But nickel also plays a key role, especially in the austenitic types such as the "18-8's" with a nominal analysis of 18% chromium and 8% nickel as the major alloying elements.

The austenitic structure is responsible for the characteristics that have made the chrome-nickel stainless steels most widely used in the stainless group.

Most common 18-8's are types 302, 304. They have corrosion resistance, ductility and toughness over a wide temperature range. Type 303 is a free-machining stainless, slightly less corrosion resistant than 302.

Two new standard austenitic compositions — AISI types 201 and 202 — have recently bowed in. Corrosion-wise they're on a par with 301 and 302. But they're lower in nickel and have 5.5 to 10.0% manganese.

Molybdenum stainless

Adding 1¾ to 4% molybdenum to austenitic stainless steels improves its corrosion resistance to a variety of acids as well as brine and sea water. This group also has the highest elevated-temperature creep strength of any standard stainless available.

Greater resistance to pitting corrosion which, as we've already seen, can occur under deposits (low-oxygen areas) that remain on stainless steels for a long time is also the result of adding molybdenum.

The basic moly stainless is type 316. A low carbon modification of it, 316L, is used where a large amount of welding fabrication is necessary.

12% chromium stainless

The 12% chromium stainless steels (actually between 11.5 and 14%) do an excellent job resisting atmospheric corrosion — weather and water. They're hardenable by heat treatment. And their corrosion resistance is greatest in the fully hardened condition.

Typical 12% stainless is type 410. It resists scaling (high-temperature corrosion) up to about 1200 F. So it's used for furnace parts operating below that temperature. Results are generally excellent.

Other alloys in this group are specialty grades. Type 403, for instance, is made for extra-high toughness applications, such as steam-turbine blading.

17% chromium stainless

Nominal 17% chromium content gives these stainless steels higher corrosion resistance than the 12% group.

Special advantage of this group is its low coefficient of expansion. Thus, if oxide scale does form, it's tight and doesn't crack off due to expansion and contraction of the metal during heating-cooling cycles.

Strength of the 17% chrome stainless types lies between chromium-nickel stainless and mild steels.

cost- and corrosion-wise against your own special needs . . .

First cost of the metal is important. But considering only first cost can lead to wrong answers. A more corrosion-resistant metal at reasonably higher cost, can more than justify itself by its greater life span, higher heat-transfer rates through the use of thin-walled sections and the elimination of corrosion products that are heat-insulating.

Major technical factors that can influence the choice of a metal to resist corrosion include temperature, velocity, and oxidizing capacity of the atmosphere, solution, soil, etc. And we talk about these where they apply throughout this report. But there are several easy-to-overlook corrosion pointers that can, in many situations, spell the difference between the right and wrong choice. Here's the gist of them.

Low-velocity corrosion test data may be misleading in predicting the behavior of a material to be used for a pump, valve, heat-exchanger tube or other equipment where metal contacts a high-velocity corrosive solution.

Vapor or gas pressure above a corrosive liquid may have a substantial effect on corrosion by changing the quantity of oxygen or other corrosive gas that may be forced into the liquid or withdrawn from it. High pressures generally tend to aggravate corrosive

20 alloy

Based on its nominal composition, 20-alloy is really a nonferrous metal since it contains less than 50% iron (approximately 45%). But because of its uses and high nickel (29%) and chromium (20%) contents, engineers consider it a highly-alloyed stainless. 20 alloy comes in both cast and wrought forms.

Costwise it lies between molybdenum stainless and the Hastelloys, Chlorimets (nickel alloys). Physical properties and welding characteristics are similar to the 18-8's. Because of its austenitic structure, it can't be hardened by heat treatment.

Relatively high erosion-corrosion resistance and reasonable cost often make 20 alloy the most economical choice for pumps, valves, piping, fittings and a variety of plant-service equipment.

Worthite, a highly-alloyed stainless (20% chromium, 24% nickel), is similar to the 20 alloys in both composition and corrosion resistance.

Nickel and its alloys

Nickel by itself, or alloyed with copper, chromium or molybdenum forms a broad group of engineering metals that show high corrosion resistance. Their strength and hardness are almost as great as carbon steel and they're endowed with ductility and toughness at sub-zero as well as high temperatures.

Although oxidizing conditions tend to promote corrosion of nickel, it can protect itself by forming a passive oxide film.

Chlorimets, containing about 60% nickel, and varying amounts of chromium and molybdenum as major alloying elements, are tops for corrosion resistance but they're relatively expensive. So you'll use them where less costly alloys will not do. They fare well in oxidizing or reducing atmospheres.

Hastelloys (grades B, C and D) contain anywhere from 55 to 84% nickel. Grade B includes 28% molybdenum. Grade C: 17% molybdenum, 16% chromium, 4% tungsten. Grade D: 10% silicon.

Corrosion resistance and strength at high temperatures are among Hastelloy's standout properties. And although they're expensive, they can be an economical solution to problems involving severe corrosion at elevated temperatures.

Monel, commercially the most important of the nickel-copper alloys (67% nickel, 30% copper), is actually more corrosion resistant — under a wide variety of oxidizing or reducing conditions — than either of its major alloying elements. And since nickel and copper are close in the galvanic series, there's no tendency to redeposit dissolved copper such as we find in the dezincification of high-zinc brasses.

Inconel's main alloying elements are nickel (77%) chromium (15%) and iron (7%). Even in strongly oxidizing solutions, Inconel is virtually free from attack. The reason: Chromium becomes passive by forming a protective oxide film.

High chromium content gives it the nod over nickel and monel in handling sulfur compounds and hydrogen sulfide at high temperatures.

Aluminum

Because of its resistance to corrosion, high strength and low cost, aluminum is most widely used of all the light metals (aluminum, magnesium, titanium). It withstands atmospheres that contain sulfides, carbon dioxide, sulfur dioxide and other contaminants. Formation of an oxide barrier controls such atmospheric corrosion.

Aluminum is corrosion resistant to pure water. But even traces of copper or iron can cause it to corrode. If you're circulating water in a closed system, inhibitors such as sodium chromate prevent attack.

High thermal conductivity of aluminum boosts heat-transfer rates in heat exchangers. And high electrical conductivity combined with corrosion resistance makes it ideal for electrochemical applications.

Clad aluminum alloys combat pitting corrosion by offering cathodic protection to the core metal. Aluminum cladding on heat-exchanger tubes, for example, acts as the anode, deflecting corrosion away from the tube base metal. Such alloys are economical too.

. . . but be sure to tap the many sources of outside help

attack by vapors or gases at elevated temperatures.

Applied stresses don't *necessarily* increase a metal's tendency to corrode. But stress effects are important. We've seen that cyclic stresses, for example, can combine with corrosion, lead to corrosion fatigue, page 79.

Heating-cooling cycles can change the corrosion-resisting qualities of some alloys. Thus if you plan to weld, forge or hot bend a metal that must be corrosion resistant, it's smart to consider the effects of such fabricating methods.

Galvanic effects are important where different metals make electrical contact in a corrosive solution. Don't forget to consider relative areas of the metals, making sure that relatively small area of the more anodic metal doesn't lead to accelerated corrosion.

Effects of corrosion product on the material being handled may be decisive. In steam and condensate systems corrosion products can build up, foul steam traps, valves and other small flow areas.

Complex as choosing the right corrosion-resistant metal is, remember that you can count on outside help too. Equipment manufacturers and metals producers have been in the thick of the battle against corrosion for many years. They stand ready to assist you in making the right choice.

Magnesium

Key to controlling corrosion of magnesium: Keeping harmful impurities out of it. For example, if iron content goes from 0.005 to 0.05%, corrosion rate climbs from 30 to 100 times in salt water. Copper and nickel have similar effects. Here's the reason: These impurities act as cathodes, cause magnesium, which is at the top of the galvanic series, to act as the anode.

Most commercial forms of magnesium include small (up to 9%) quantities of aluminum, manganese and zinc to offset harmful impurities present.

Copper and its alloys

Either in its pure form or alloyed with zinc, tin, lead, nickel, aluminum, silicon or manganese, copper has good all-around corrosion resistance. Add to this its excellent thermal and electrical conductivity and you've pinpointed the main reasons for its popularity.

Arsenical admiralty (70% copper, 29% zinc, 1% tin, 0.03% arsenic) shows good corrosion resistance to most waters and does a top job in sea water at velocities less than 6 fps.

Manufacturers add arsenic to the metal to inhibit plug and layer type dezincification.

Muntz metal (60% copper, 40% zinc) is used where corrosion resistance must join forces with high strength, moderate ductility. Common applications include condenser heads, tubes and tube sheets, baffle and support plates in heat exchangers.

Red brass (85% copper, 15% zinc). Because of its natural resistance to dezincification red brass is often favored over other copper alloys for heat exchangers and plumbing piping.

Cupronickel alloys that contain 10 to 30% nickel are often picked as heat-exchanger tubes because they resist corrosion by salt water used for cooling. More recently, engineers have been swinging over to these alloys for tubes in feedwater heaters, largely because they do a good job at high temperatures.

Aluminum brass (78% copper, 2% aluminum, 0.03% arsenic, balance zinc) naturally more resistant to corrosion than admiralty — both from fast-moving sea water as well as polluted waters found in harbors and rivers contaminated by sewage and wastes — has been replacing admiralty in a substantial number of installations. It's well suited to condenser tubing where inlet-end corrosion or impingement corrosion is a serious problem.

Bronzes generally contain significant amounts of tin in addition to copper and other alloying elements. Common types include silicon bronze, phosphor bronze and manganese bronze. Their corrosion resistance is on a par with the copper-zinc alloys.

Zinc

Major uses for zinc in combatting corrosion are (1) Protective coatings for metals — applied by galvanizing, metallizing, sherardizing. We'll have more to say about these later. (2) As galvanic anodes, see pp 80-81. (3) As pigments for corrosion-resistant paints. These are zinc, zinc oxide, zinc chromate.

Corrosion rate of zinc in water is much lower than iron, slightly higher than copper. But, as with other common metals, temperature, pH and oxygen-concentration effects can alter the picture considerably.

Tin

Because tin is a low-melting-point metal we don't use it where high-temperature corrosion is likely to be a problem. But it does a top job as a protective coating over steel and in such alloys as bronze.

An invisible film of stannic oxide normally covers tin. But acids, alkalies can cause pitting.

Distilled, soft tap water doesn't corrode the metal. And adding 5% antimony avoids localized corrosion.

Lead

Corrosion resistance of lead depends on a thin protective coating — either an insoluble lead salt or a soluble film. First type resists attack even where the film suffers mechanical injury, because the environment promotes self-healing. By contrast, the soluble film can dissolve in the solution or atmosphere surrounding the lead, leave it open to corrosive attack.

Neutral solutions tend to build up the protective film (lead carbonate, oxide). Low pH solutions show varying rates of attack.

Chemical lead, acid lead and copper lead are common commercial grades. Common power-service jobs for it include: lead-sheathed cable, lead-covered pipe. gaskets and lead-clad copper heating coils.

Tantalum

Strongly resistant to most corrosives, tantalum is used mainly for heat-transfer equipment — heating coils, coolers, instrument-bulb protection. The metal performs well even under some corrosive conditions that bar the use of gold or platinum. Thus its relatively high cost is justified on a necessity basis.

Tantalum is produced by powder-metallurgy methods. Its chemical properties resemble those of glass.

Titanium

Relative newcomer to the metals field, titanium is one of the most corrosion-resistant metals known. It ranks among the best metals available in its ability to resist the action of sea water. And it can be heated to 1100 F without high-temperature oxidation effects.

Biggest drawback of this *wonder* metal: Its inability to compete with other metals on a cost basis. But its price has been dropping steadily.

INERT BARRIERS — organic, metallic and vitreous forms

Generally speaking, inert barriers include all organic, metallic, vitreous and wood barriers applied between metals, alloys and their corrosive environment.

Going a step further, we can subdivide organics into *coatings, mastics* and *linings*. Coatings are films 5 to 20 mils thick. (Corrosion engineers find that when total coating thickness is less than 5 mils it doesn't give reliable protection). Linings are films 60 mils thick and greater. Mastics fall in a range between these two.

You can use barriers by themselves or combine them with other methods of corrosion control. Often, combination control is most effective, economical. Underground

ORGANICS — should you use coatings, mastics or linings?

Most popular weapons in the corrosion engineer's arsenal are protective organic barriers. Pictured above are the most common ways of applying them.

To get maximum service life from most coating systems, films should be applied in a minimum of three coats and, as we've already seen, be at least 5 mils thick.

Right surface preparation — sandblasting, etching, wire brushing — plays a key part in getting good results from organic barriers and is particularly important if you plan to use thin coatings. For most jobs best preparation is sand blasting. Resulting clean, rough surface provides excellent mechanical bonding qualities.

Barriers made from synthetic as well as natural resins are available in a wide variety of types. But as we'll see in the following sections, it's possible to classify them according to similar performance, characteristics, etc.

Elastomers

Most important application for this group: Linings for equipment designed for highly corrosive conditions. But they're also widely used as coatings.

Made from both natural and synthetic resins, elastomers include rubber barriers — natural rubber, neoprene, butadiene-styrene rubber, butyl rubber, and nitrile rubber. Their resilience make them a good choice where abrasion and impact are likely to be doing their treacherous work hand-in-hand with corrosion.

In selecting an elastomer barrier be sure to investigate its bonding properties. Most of the common elastomer barriers will not adhere directly to metal. They're usually applied over a chlorinated-rubber primer.

Neoprene-based coatings—resistant to non-oxidizing acids, salts and alkalies up to 150 F — are used for lining vessels and storage tanks, especially where intricate shapes make it difficult to get full protection with a lining material. Natural rubber also fits for such applications.

Thermoplastic

Applied thermoplastic films — vinyls, polyethylene, vinylidene chloride, saturated oils, waxes, bitumens — require no further curing after they're applied, but elevated temperature softens them.

Vinyl material compositions vary substantially, depending on where, how they're to be used. Manufacturers add plasticizers (to keep vinyls from becoming hard, brittle) and heat stabilizers in varying amounts to suit customer needs. Vinyls, when you apply them according to manufacturers' specs, yield a general-purpose coating that has excellent resistance to oxidizing materials.

Polyvinyl chloride (PVC), popular member of the vinyl group, is a tough, resilient barrier that you can use either as a liquid to form thin films or as sheets that can be cemented to metal's surface. PVC protective tapes can be your answer to underground pipeline protection problems.

Relatively new vinyl is a high-solids aluminum coating. Aluminum is present in finely divided particles — virtually liquid aluminum. In coating form it protects tanks, coils against the action of oils, mild corrosives.

Polyethylene has excellent resistance to oxidizing agents. Its versatility, low cost make it highly popular.

Polyfluoroethylene, one of the newer materials in this group, features outstanding chemical resistance to most corrosives up to about 500 F. But it's relatively tough to apply.

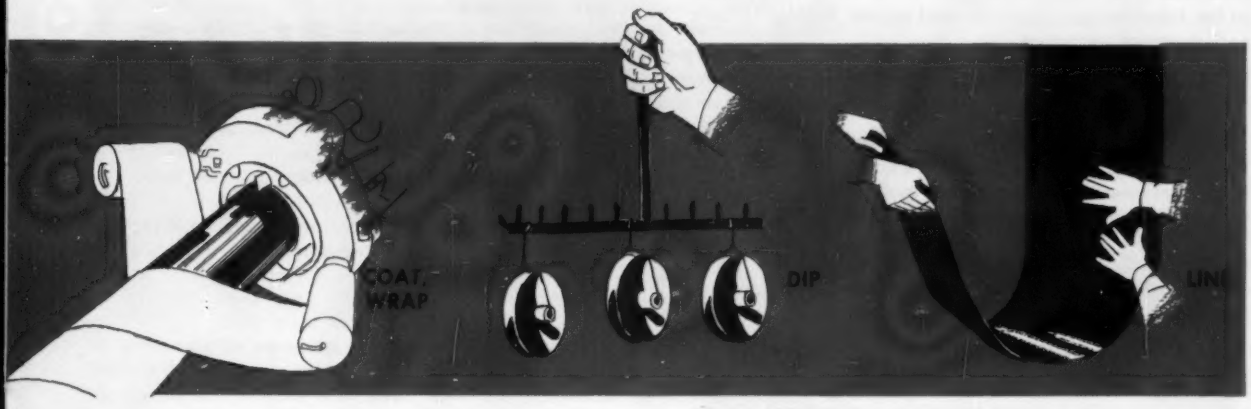
Vinylidene chloride, derived from ethylene and chlorine, is a highly corrosion-resistant barrier. Important application: Lining piping, tanks where corrosives are present.

Bitumens — either coal-tar or asphalt base — soften at high temperatures. Thus we consider them thermoplastic.

stand between your plant equipment and corrosive attack

pipelines, for example, are coated to reduce current flow needed for cathodic protection.

Choosing the form. From a practical viewpoint, giving the nod to either a coating, mastic or lining boils down to pinpointing the required thickness for adequate protection. Thus, service conditions must be weighed carefully. Is the equipment subject to rough handling, abrasion? How fast will corrosion take place? (Corrosion speed is commonly measured in inches per year, ipy. Engineers consider that rates greater than 0.05 ipy indicate highly corrosive conditions). These are just a few of the important questions corrosion men must find answers to.



Size up corrosion conditions, cost before making your choice

Both the coal tar and asphalt base types give good protection — especially for coating underground pipelines in the field. To reinforce these organic barriers against soil stresses, cloth, jute, burlap, glass-fiber tapes and other materials are wrapped between coating layers.

Another recent anti-corrosion application of coal-tar paints: Coating submersible-type transformers and network protectors where salt that's used for snow and ice removal contaminate ordinary paints.

Thermosetting

Like the elastomers, thermosetting barriers often need further processing — baking for example — after they're applied, to develop their best properties. Thermosetting films are tough, rigid and resist high temperatures. They're highly versatile engineering materials.

Alkyds. These can be either thermoplastic or thermosetting. But the latter is their most important commercial form. Excellent durability under a wide range of exposure conditions makes them most popular of the resins used in protective coatings.

Alkyds are often blended with other resins to get special protective properties. So-called oil-modified alkyds (with drying oils) are quick-drying coatings that produce a good general-purpose industrial finish.

Phenolics have been a mainstay of industry for many years. Major types are: (1) baked (2) air-dried.

Baked types are heated to about 350 F after applying them. Because specialized equipment, experience is a must in turning out good baked phenolic coatings they're normally applied by specialists in well-equipped shops.

You can consider using phenolics up to 350 F, except where oxidizing agents are present. Tanks, vessels protected by such baked coatings can be steam cleaned.

Brittleness — until recently a major defect of baked phenolic coatings — can now be overcome by epoxy-phenolics.

Epoxy resins — comparative newcomers to the field — are much like the phenolics. And engineers are using them in substantially the same way. They have good corrosion resistance in both baked and air-dried forms.

Major advantage is their greater range of corrosion resistance than the phenolics. Also important: They have excellent flexibility and bonding properties.

Oleo-resinous materials are really a special class of thermosetting barrier that's formulated from natural rather than synthetic materials. A drying oil is the ingredient common to all types in this group.

Most important oleo-resinous materials from the plant engineers' viewpoint: oil-base paints. They're relatively low cost, easy to apply, can build up to the minimum 5 mil thickness in fewer coats than the average synthetic. And they possess excellent resistance to weathering. Thus, they're favored for general outdoor anti-corrosion maintenance.

Corrosion-inhibitor pigments such as red lead, white lead, zinc chromate, iron oxides, zinc oxides and aluminum powder fortify many of the oleo-resinous paints for corrosion combatting applications in the plant.

Silicones and their various modifications have moved into the corrosion picture in a big way only within the past few years. And they're fast winning favor among corrosion engineers — especially for high temperatures.

Silicone varnishes have been pigmented with aluminum powder to protect steel surfaces at temperatures to 1000 F. They've successfully protected steel stacks for many months at 400 to 800 F. where other organic finishes failed.

Combining silicones with alkyd, phenolic, amine resins yields a finish that's less brittle, more adhesive to steel. But these combinations generally have somewhat lower heat resistance than the straight silicone barriers.

METALLIC COATINGS — how you can get lower-cost protection by using higher-cost metals

When you need the protection afforded by expensive, often hard-to-come-by metals but can't justify them costwise, metallic coatings are a likely answer to your problem.

A wide variety of metallic coatings are available commercially. But not all of them are applied primarily to resist corrosion. In the paragraphs that follow we limit ourselves to the common types that are used mainly because of their anti-corrosion properties.

ZINC

Zinc coats on steel take on a dual function: First, they keep steel from rusting by preventing contact with corrosive atmospheres—outdoors as well as indoors. Second, zinc protects the base metal by cathodic protection.

Metal's low melting point allows it to be conveniently applied to steel in controllable thin coats at low cost. Thus, it's applied in several different ways: hot-dip galvanizing, electroplating, spraying (metallizing), cementation (Sherardizing) and vapor condensation.

While zinc does a first-rate job resisting atmospheric corrosion (an average 2-oz-per-sq-ft surface coating lasts about 15 years in a highly industrial atmosphere) it's not frequently used at 450 F or above. And strongly acid or alkali conditions cut its life expectancy substantially.

NICKEL, CHROME

Nickel and chromium coatings find widest use where they must not only resist corrosion, but maintain lustre.

Protection you'll get from these coatings varies with their thickness, nature of the base metal, type of corrosive atmosphere, thickness being the chief factor. 0.5-mil thickness in mild atmospheres is roughly equivalent to 2.0-mils in industrial areas. A 1.2-mil coating on steel does about the same job as 1.0 mil on zinc or 0.4 mil on brass.

Coatings tend to be porous if they're less than 1.0 mil, exposing the base metal intermittently. When atmosphere attacks the metal, porosity increases, making the base metal an easier target for corrosion.

Copper undercoats reduce plating costs. But they don't offer as much protection as the same thickness of nickel. Their value varies with different atmospheres, thicknesses.

Electrolytic nickel-clad steel plate, with coating thickness anywhere from 0.006 to 0.020 inches, is moving into the fabricated industrial parts picture in a big way. Corrosion-wise, clad steel shows many of the same properties as solid nickel — and at substantially lower cost.

Chrome coatings usually have a nickel undercoat to improve corrosion resistance, reduce costs.

TIN

Hot-dipped tin coatings on steel sheets account for the bulk of tin used in the U.S. Resulting *tin plate* goes almost entirely into cans. But tin coatings on iron and steel also hold down important anti-corrosion jobs in industry.

The usual hot-dip process yields coats that are 0.5 to 1.0 mil thick. Electrolytic techniques, because they do a better job controlling thickness, produce coatings as thin as 0.015 mil. In either case rusting can start at tiny breaks (pinholes) and spread. Thus, if you're considering tin coatings that must stand up for long periods, even in mildly corrosive atmospheres, be sure coating thickness is enough to keep pinholes to a minimum. Good practice on many industrial jobs calls for 2 to 5 mils.

ANODIC COATINGS . . . getting protection with oxide films

Neither metallic nor paint, these coatings have made their mark within the past few years. Most important and widely used of this type is the oxide film that forms on aluminum when it's treated electrochemically. Although the oxide film that results is much like the natural oxide film normally found on aluminum, the anodic coating is thicker, provides more corrosion protection.

One of the chief uses for these coatings: Providing a base for paints, lacquers.

Anodic coatings on magnesium and zinc offer less protection than those on aluminum.

CADMIUM

In much the same way as zinc, cadmium performs a dual-protection role: It acts as a barrier and, to some extent, it supplies cathodic protection.

SO_2 and SO_3 in the atmosphere severely corrode cadmium plating. Ammonia fumes and hydrogen sulfide can also break down cadmium — especially where humidity is high.

LEAD

Compared to other inexpensive coating metals, lead's big advantage for above-ground corrosion problems is its resistance to a variety of acids and brines. Engineers use it to line process tanks, piping, pumps and other equipment.

Lead's ability to resist soil corrosion depends largely on minimizing porosity. Thus, thick lead sheaths — commonly used on underground cable — show good resistance in a variety of soils that attack thin coatings. To get good results with lead coatings underground, soils need to be well drained, have relatively high resistivity.

ALUMINUM

Aluminum coatings provide a barrier against corrosion by forming highly resistant oxide films on their surfaces. Once the film establishes itself oxidation tapers off rapidly. And breaks in the film are self-healing.

Important job for these coatings: Protecting ferrous metals at relatively high temperatures.

Aluminum cladding — forming a layer of protective aluminum over the base metal by hot rolling a bi-metal ingot — produces a corrosion-resistant barrier that's always anodic. So even exposed points get cathodic protection.

VITREOUS BARRIERS—porcelain enamels resist corrosion to 1000 F, ceramic coatings to 2000 F as today's temperature frontiers move up

Porcelain enamel and its high-temperature twin, ceramic coatings, form a group of inert barriers that may fit into your corrosion-control program in several important ways: The porcelain enamels (also called glass linings) do a top job protecting equipment from attack at temperatures to 1000 F. Ceramic coatings work well to 2000 F. They can be instrumental in giving added life to expensive metals. Or, by using these coatings, you may be able to substitute a lower-cost metal for one you're now using.

The acid resistance of porcelain enamel is a pretty good indication of its resistance to corrosion in general. With the right type, you can ward off the corrosive effects of practically all acids except those that dissolve silicates, the basic material from which porcelain enamel is made. That's why these barriers are widely used to line heat exchangers, storage tanks, pumps and a host of other industrial service equipment.

Vitreous barriers go back many years, even to ancient times. But they first moved into the industrial picture about 100 years ago. Cast iron provided the base metal in those days and it still looms large today as a porcelain-coated material. But new metals — mainly steels — and applications have since added to the versatility of glass linings.

The wet process applies the barrier to the metal as a slurry by dip or spray. Dry process, used only on castings, applies the coating as a powder. Crucial factor in both of these processes: Making sure metal to be covered has few, if any, surface defects that can cause headaches during firing.

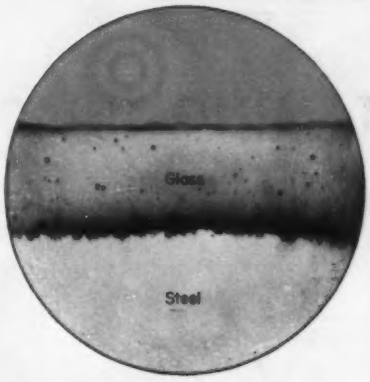
After barrier is applied, its *fired* at temperatures as high as 1650 F for several minutes or more. Exact temperature, time depends on barrier used, metal thickness, where it will be used. Barriers go on in one or more layers and each one is fired separately.

Life you can expect depends, largely, on choosing the right coating to suit your needs and avoiding mechanical injury, chipping for instance, to it. With reasonable care, vitreous materials can last many years.

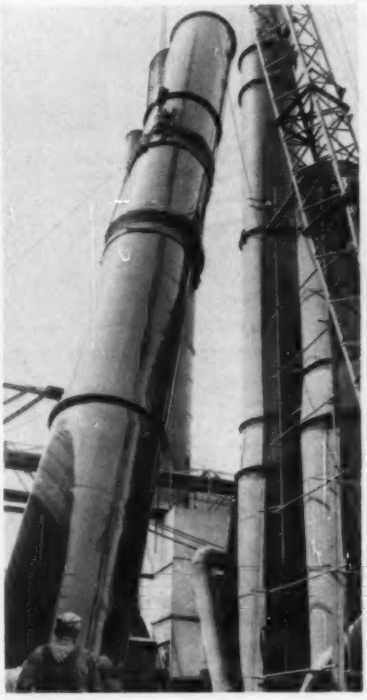
Bonding. While there's less than full agreement among the experts on the mechanism of coating bonding to the metal we can, for all practical purposes, say that it's a combination mechanical-chemical action. The enlarged (200 diameters) view of glass lining bonded to steel, *top right*, shows that the two are inseparably fused.

Refractory ceramic coatings' job is to protect the high-temperature alloys from high-temperature oxidation, a form of corrosion we talked about on page 78. Upper limits for such coatings are pushing beyond 2000 F in the gas-turbine field.

In addition to their corrosion resistance, the ceramic coatings can take thermal shock, resist chipping, cracking, blistering and erosion by high-velocity hot gases. But to develop best properties many of these coatings must be extremely thin—a few thousandths of an inch or less. So controlling their thickness is critical.



THE INSEPARABLE BOND that forms between glass lining and steel depends largely on combined mechanical-chemical action. But experts differ on the mechanism that causes the coating to adhere



Glass linings are proving themselves on steel stacks

The glass-lined — inside and out — steel stack being installed above has been in service more than two years. And results thus far point up its excellent possibilities.

The glass coating eliminates accelerated corrosion engineers often run into at low flue-gas temperatures. And, compared to brick-lined stacks, they're considerably lighter. Thus, foundation and support requirements are less.

Present cost of the glass-coated stack is about 50% more than for an unlined steel stack. But expected life jumps approximately 100%.

Glass as a piping material

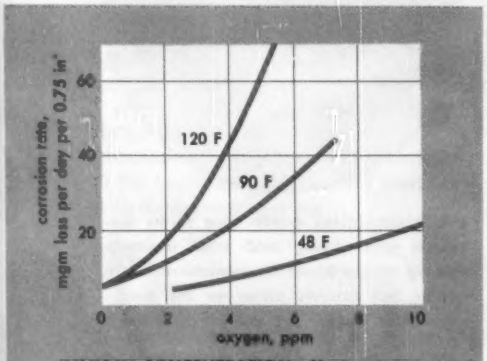
While glass has some obvious natural limitations as a piping material it also has some big advantages. Its corrosion resistance, under a variety of conditions, is excellent.

Although glass is attacked by water at temperatures greater than 300 F, temperature isn't a bar to satisfactory service. But high-temperature combined with high-alkalinity can be a headache.

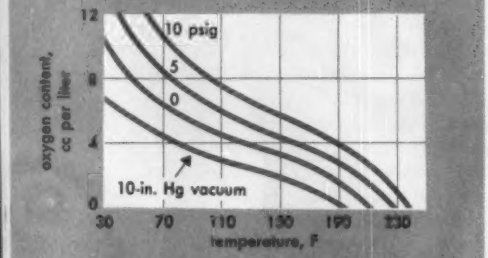
Today's glass piping is making sizable gains in the food, pharmaceutical and chemical process industries — largely because of its corrosion resistance. It's available in standard sizes from one to six inches.

TAMING THE CORRODENT— part of a two-pronged

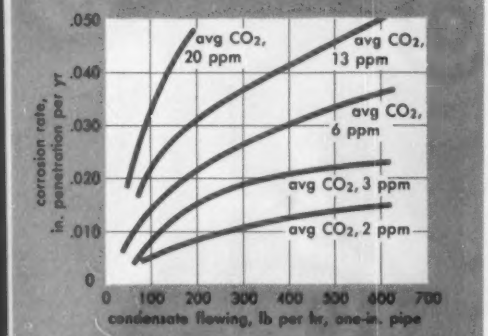
So far we've talked about ways of warding off corrosion by improving the metal's ability to resist corrosive attack — either by cathodic protection, alloying elements, organic, metallic and vitreous barriers. Now we go at the problem from another angle: Taming the attacking medium. This approach applies mainly when we deal with liquid-media corrosion problems. And, often, we team it up with techniques already discussed.



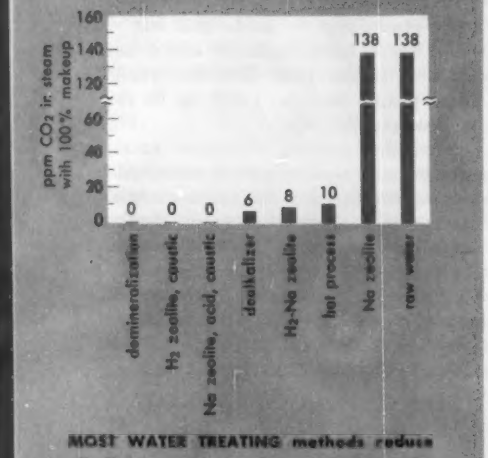
OXYGEN-CONCENTRATION effects on corrosion rate at various temperatures



OXYGEN SOLUBILITY in water at different temperatures and pressures


corrosion rate, in. penetration per yr
avg CO₂, 20 ppm
avg CO₂, 13 ppm
avg CO₂, 6 ppm
avg CO₂, 3 ppm
avg CO₂, 2 ppm
condensate flowing, lb per hr, one-in. pipe

CARBON-DIOXIDE content and condensate flow affect the rate of corrosion



MOST WATER TREATING methods reduce alkalinity content, thus reducing CO_2

Eliminate dissolved oxygen

Corrosion fundamentals, pages 74-77, showed us how oxygen attacks metals, reacting with hydrogen at the cathodic surface, forming water and depolarizing the surface, permitting additional metal to dissolve. Graph, *top left,* shows the effect of oxygen concentration on low carbon steel at different temperatures. Notice that while the effects of oxygen are relatively mild at lower temperatures, corrosion rate more than doubles when temperature goes from 90 to 120 F.

Chief source of dissolved oxygen in water is the atmosphere. Deep well waters are usually devoid of oxygen, while most surface supplies are saturated with it.

Solubility of oxygen in water depends on temperature and pressure. Graph, *second from top, left,* points up their combined effects: (1) Increased pressure increases oxygen solubility. (2) Increased temperature lowers oxygen solubility. We use these facts in reducing water's oxidizing capacity. Here's how:

Deaeration, the removal of dissolved gases such as oxygen and carbon dioxide, raises water to its saturation temperature corresponding to deaerating pressure. Deaerating heaters are designed to mix water with scrubbing steam. They also vent released gases.

Principle deaerating heaters are the tray, spray-reboiler and jet-atomizing types. But sometimes, in central-station operation, we deaerate in surface condensers that have deaerating hot wells. Condenser spills condensate into hotwell through a steam atmosphere.

Sodium sulfite, a chemical deaerant, combines with oxygen, to form sodium sulfate. Reaction is a fast one at 212 F and above. Thus we feed sulfite to boiler water. Best pH for this reaction is 9.0-10.0.

Hydrazine, a reducing agent that's been getting much attention recently, reacts with oxygen, forming water and nitrogen. Advantage of this material: no additional salts form in the reaction. (For more info on hydrazine see Power, Nov. 1956, pages 80-82.)

Reduce carbon-dioxide content

Oxygen is roughly five to ten times more corrosive than carbon dioxide. But the two gases acting together are 10 to 40% more corrosive than the same quantity of the two gases acting separately.

Carbon dioxide dissolved in water forms carbonic acid, a relatively unstable compound. Only in the form of carbonic acid can a gas solution pressure be exerted — a necessary condition for removal of free carbon dioxide by deaeration. Thus, most efficient carbon-dioxide removal requires lower (more acidic) pH values.

Chief source of carbon dioxide in condensate is the bicarbonate and carbonate alkalinity of boiler makeup water. High temperatures cause them to decompose and liberate carbon dioxide that becomes entrained in steam.

Curves, *second from bottom, left,* show that when other conditions are constant, corrosion is proportional to carbon dioxide concentration of condensate. Even up to 5-ppm carbon dioxide, corrosion generally isn't serious. A close look at the bar graph, *bottom, left,* shows that several water-treating methods can meet these requirements by reducing alkalinity.

Alkalies and phosphates have limited application for neutralizing

attack on your corrosion problems

Is changing the environment a better way to handle corrosion problems than protecting metal likely to be attacked? There's no pat answer. It's largely a question of economics and technical requirements of the power service or process. But the methods we highlight below represent generally accepted practice. For more detailed info, see Power Special Report, "Fundamentals of Feedwater Treatment," December 1947.

carbon dioxide in steam. Difficulty in evenly dispersing the treatment throughout steam, and objection to adding inorganic solids are drawbacks.

Ammonia neutralizes carbon dioxide in central-station systems with low makeup. It's fed as ammonium hydroxide or ammonium sulfate. Ammonia can do a good job in protecting ferrous metals. But copper and zinc bearing materials are likely to corrode.

Neutralizing amines (cyclohexylamine, morpholine) can safely neutralize carbonic acid. Unlike ammonia, the amines in low concentrations aren't corrosive to copper, zinc. Their main limitations: (1) They provide no protection against oxygen attack. (2) They're relatively high cost.

Filming amines (octadecylamine, dioctadecylamine) deposit a protective non-wettable film on the metal's surface. Thus, they protect against oxygen as well as carbon dioxide attack. And film doesn't break up during short periods when you must interrupt treatment.

Keep pH within right limits

At pH values below approximately 4.5, free mineral acidity exists and can cause serious corrosion. Waters saturated with acid drainage, for example, are highly corrosive. So neutralizing them before use is essential. But in the range of most natural waters, especially where oxygen is present, pH isn't the controlling factor. Graph, *top right*, shows that when we eliminate carbon dioxide and effects of other contaminants, corrosion rate of pure zinc is low when water is between pH 6-12.

Soda ash and caustic soda are alkalies that neutralize acidic characteristics of boiler feedwater. Except in special cases of high-pressure boiler operation, chemical consultants recommend pH of approximately 10.5. But by treating for scale, sludge, you maintain correct pH automatically.

Control humidity

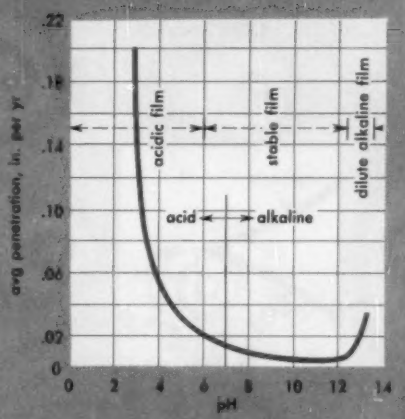
While reducing humidity doesn't fall under the heading of liquid-media corrosion problems we include it here because it *does* change the metal's environment.

Except at elevated temperatures, clean dry air doesn't corrode metal. Moisture and / or contaminants are essential ingredients in the corrosion process. Graph, *second from top, right*, shows results of atmospheric corrosion tests on mild steel. Critical relative humidity is in the neighborhood of 65%. Above this figure corrosion rate climbs rapidly — especially where other impurities are present. Thus, air conditioning is the corrosion engineer's ally.

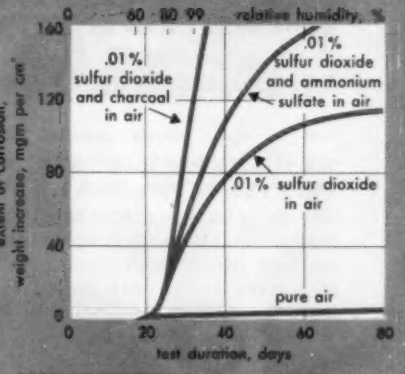
Cut back liquid's speed, temperature

Trimming liquid temperature and speed can go a long way toward minimizing corrosion. Two lower graphs, *right*, show trends. Velocity curve plots a test on water at 120 F. Higher liquid speeds boost depolarizing effect by bringing larger quantities of oxygen into contact with the cathodic surface.

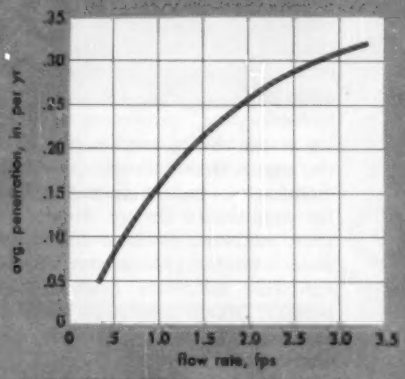
Notice, on bottom graph, that in systems where oxygen is free to escape, temperature effect is less severe. At saturation temperature, corrosion rate dips sharply.



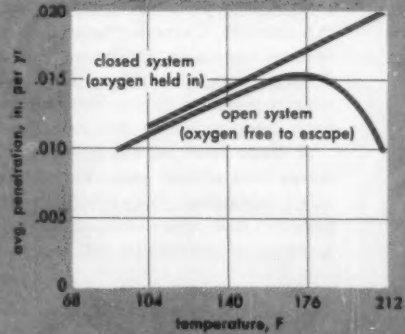
CORROSION RATE is low over wide pH range when corrosive gas isn't present



HIGH HUMIDITY speeds corrosion, especially when the air contains contaminants

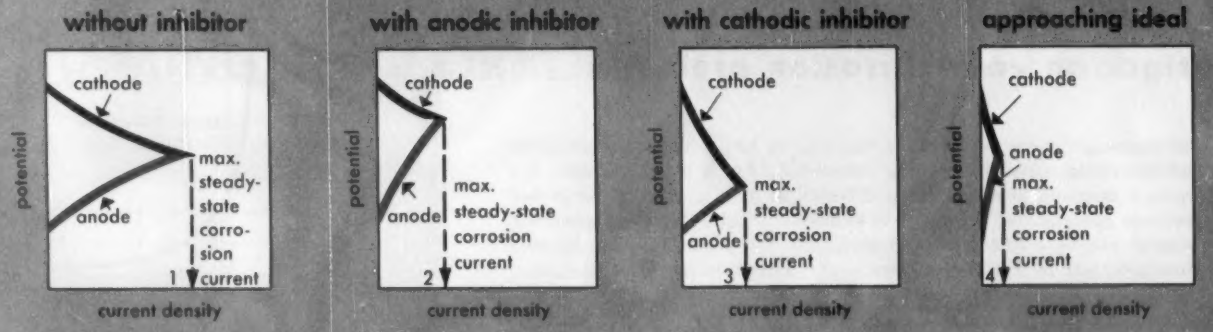


HIGH VELOCITY tends to depolarize metal, thus increasing corrosion



HIGH TEMPERATURE boosts corrosion except where oxygen is free to escape

How inhibitors polarize corrosion cells



INHIBITORS—these chemical compounds control corrosion by polarizing anodes or cathodes—or both

We talked about some inhibitors of importance to power men when we considered ways to protect against carbon-dioxide attack. Here we'll consider inhibitor use—inorganic and organic—as a major technique of the corrosion engineer. Inhibitors are especially important in water-supply systems, circulating-water systems for cooling and air conditioning, steam and condensate lines, brine systems.

Inhibitors are classified in various ways, depending on which yardstick you want to use. On the basis of their chemistry they're inorganic (sodium dichromate, sodium nitrite, etc.) and organic (glucosates, amines, phenylhydrazine, etc.). According to polarizing action they're anodic (phosphates, chromates, etc.), cathodic (arsenic and nickel salts, etc.), or general (gelatin). By application they're divided into brine inhibitors (sodium dichromate), water inhibitors (phosphates, silicates), antifreeze inhibitors (sodium tetraborate), steam-condensate inhibitors (amines, hydrazine, sulfites, phosphates, etc).

Inhibitors generally retard corrosion by increasing polarization rate at either the anode or cathode metal—or both. Anodic types polarize the anode—they shift anode potential toward that of the cathode. Cathodic types take the reverse approach. Inhibitors can also do their job by building up an electrically resistant film in the conduction path between anode and cathode.

A close look at the graphs above shows how anodic, cathodic inhibitors affect corrosion. We've already seen, page 77, that when current flows in a galvanic or electrolytic cell, anode and cathode potentials tend to shift toward each other. Corrosion current density, 1, corresponds to maximum possible corrosion rate without inhibitors. A compound that can boost polarization at the anode moves limiting corrosion current density to 2, thus reducing corrosion rate. We can get the same effect by increasing polarization at the cathode, 3. Corrosion would be completely stifled if anode, cathode potentials converged at negligible current density, 4.

Anodic inhibitors, if they're not used right, can actually accelerate corrosion. Here's how: In talking about fundamentals, page 77, we saw that corrosion rate is proportional to current flow per unit area. If it's proportional to the anode area (anode control), drop in corrosion rate depends on how much of anode area is polarized. But if current flow is limited by cathode area (most common corrosion type) corrosion isn't affected by decreasing the anode areas. Thus, if you use an anodic inhibitor in low concentrations, it may not be sufficient to protect the entire surface. Result: Concentrated pitting.

Inorganic inhibitors and corrosion systems in which they are effective

Inhibitor	Approximate inhibitor concentration, %	Corrosive environment	Metallic system
Glassy phosphates	Small amount	Water systems	Steel
Potassium dichromate	0.05-0.2	Tap water	Iron-brass
Potassium dihydrogen phosphate + sodium nitrite	Small amount + 5	Sea water	Steel
Potassium permanganate	0.10	0.30 N NaOH solution	Aluminum
Sodium benzoate	0.5	0.03% NaCl solution	Mild steel
Sodium carbonate	Small amount	Gas-condensate wells	Iron
Sodium chromate	>0.5	Cooling water	Electrical rectifier systems
Sodium chromate	0.07	$CaCl_2$ brine	Cu, brass
Sodium dichromate	0.025	Air-conditioning water	Air-conditioning equipment
Sodium dichromate + sodium nitrate	0.1 + 0.05	Water	Heat-exchangers
Sodium hexametaphosphate	0.002	Water about pH 6	Lead
Sodium metaphosphate	Small amount	Ammonia	Mild-steel condensers
Sodium nitrite	0.005	Water	Mild steel
Sodium nitrite	20% of sea water	Sea-water/distilled water mixtures	Mild steel
Sodium orthophosphate	1	Water pH 7.25	Iron
Sodium silicate	Small amount	Sea water	Zn, Zn-Al alloys

TEMPORARY PROTECTION—how to combat corrosion of metal parts during shipment and storage

In a class by themselves because their chief job is to protect all kinds of fabricated metal parts while they stand idle during storage, shipment and between manufacturing steps, temporary preventives are an indispensable tool of the corrosion engineer. Actually, tagging them "temporary" is misleading because their protective qualities may be equal or superior to permanent coatings during their applied life.

Essential features of any temporary preventive: It must be easy to apply, and even more important—easy to remove. While it's on the metal it must stand guard against the corrosive effects of humidity, fumes, fingerprints, weathering and water. These coatings also prevent mechanical damage—nicks, burs—and preserve metal's original appearance.

The major preventives include (1) grease types (2) oil types (3) solvent types (4) strippable plastic types. Each has special advantages, limitations.

Grease preventives are thick-coat compounds that won't melt or flow at ordinary room temperature. Materials range from soft petrolatums to hard wax-like compounds. Softer coatings are for moderate shipping and storage temperatures. Harder coatings stand up under higher temperatures.

Dipping in heated tanks is the usual way of applying the greases. And, except for some hard *solvent-drying types*, they require the most time and effort to remove.

Oil preventives include the non-drying, non-setting oils of various viscosities. But even with the heaviest of these oils, protective films won't be thicker than .0002 in. And they attain final thickness by draining only—without setting or drying.

Solvent cut-back preventives can be subdivided according to the solvent and material dissolved in it.

(1) *Dry-type films: asphaltic resin and waxy.* These are thin, fairly hard films that look like varnish. They're on a par with protection you'll get from heavy greases. And they withstand abrasion, handling.

(2) *Water-displacing:* These usually contain substantial amounts of soap-like materials that actually remove droplets of water from metal surfaces by "preferential wetting." Preservatives' attraction toward the metal surface is greater than that of water, displacing the water. Big reason for their use: They save time, labor by permitting the easy preservation of wet parts in one simple dip.

(3) *Fingerprint removers:* These contain water, an organic solvent and preserving additives. After fingerprint residues—acidic organic materials, salt, etc.—are dissolved, the additives form a protecting film. For long-term storage remove this film and replace it with a more lasting preservative.

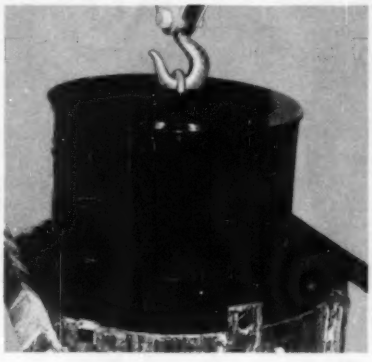
(4) *Combination solvent preservatives:* Solvent is combined with either an oil, grease or wax-type preservative. If solvent content is low and you spray or brush it on, final film is relatively thick—comparable to greases. But, more often, these films are thin.

(5) *Water soluble compound* is a low-cost coating from which the water evaporates, leaving an oily film.

Strippable plastics are a combination of special oils, plasticizers, inhibitors, synthetic resins and plastics. Coatings are thick, from .050 to .100 in. And they have several unique features: They'll give you top corrosion as well as mechanical protection. And you can easily remove them by slitting and peeling. These coatings are applied from hot tanks.

First essential step, before you can use any of these coatings is thorough cleaning of the metal. Here are common ways: (1) Mechanical—sand blasting, tumbling, shot blasting, scratch brushing. (2) Chemical—solvents, alkalies, emulsions, electrocleaning.

BEFORE: Bearing sleeve about to be dipped in solvent preventive, will be stored for many months before use



AFTER: Solvent preventive not only wards off rusting but won't scrape off when sleeve is assembled for shipment

CONSIDER THESE POINTS . . .

Before choosing a cleaner

- What kind of dirt do you want to remove?
- How clean must metal be?
- Will cleaner chemically attack the metal?
- Are there any major safety hazards involved—fire, toxicity?

Before choosing a preventive

- What are storage conditions like—temperature, humidity?
- How long must corrosion protection last?
- What facilities do you have for applying, removing coatings?
- What about functions other than protection—lube qualities?

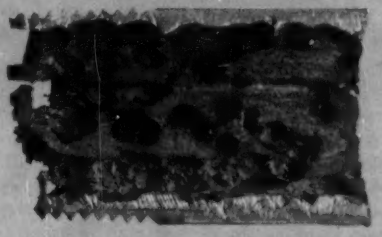
Now let's put anti-corrosion tools to work

Having viewed most of the major weapons available to combat corrosion we're in much the same position as the general who must decide where to use his heavy artillery and where to use his infantry—and how one can best back up the other.

In getting the most from our corrosion arsenal we must decide whether corrosion-resistant metals alone can beat off the attack or whether they must be backed up with inert barriers. Is it smart tactics to go along with cathodic protection? If so, to what extent? To come up with the right move we—like the general—must know our enemy. What's more, we must know how he'll act under specific battlefield conditions. Our battlefields are the steam and condensate systems, cooling-water systems, combustion systems and a host of other likely targets for corrosion.

In the next ten pages we'll get to know how the enemy acts under a variety of field conditions. And we'll see which weapons give us an effective defense. In considering them we'll take into account economic as well as technical requirements that need to be weighed carefully.

OXYGEN PITTING is caused by liberated air bubbles that attach themselves to metal, start localized attack



GROOVING, PITTING in this condensate return line is due to action of carbon dioxide in dissolved form

HEATER FAILURE due to combined erosion-corrosion. High-speed steam prevented buildup of protective rust

Corrosion in steam and condensate systems . . .

As operating temperatures and pressures for power-service equipment continue to climb, corrosion problems in steam and condensate systems become more complex. And — if you ignore them — they become more costly.

Common chief offenders when it comes to steam and condensate return-line corrosion are oxygen, carbon dioxide and ammonia. But they must be in solution before they become aggressive. Other influencing factors are condensation rate, contact time, temperature, galvanic action, low pH.

Oxygen in steam and boiler feedwater can stem directly from the water itself or it can enter at various points in the condensate system. Good practice calls for heating makeup water to its saturation temperature in a deaerating heater, lowering oxygen's solubility (see curves, page 90). Separated oxygen is vented. Deaerating heaters can remove virtually all oxygen.

In vacuum return systems or in gravity systems, oxygen can infiltrate. Even where the system is under pressure, oxygen finds its way in during down time.

Cooling water, often injected into vacuum pumps to lower condensate temperature, usually contains substantial amounts of dissolved oxygen. Controlling water temperature thermostatically keeps oxygen to a minimum. Also, catalyzed sodium sulfite can be injected. It reacts with oxygen, eliminating it from cold water.

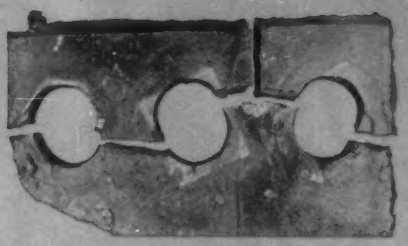
You can spot carbon dioxide—the usual cause of steam and return line corrosion—by its general thinning of the pipe wall or grooving along the bottom. The chief source is the bicarbonate and carbonate alkalinity of makeup water.

Today's thinking on handling the CO_2 problem takes a variety of forms. Hot lime-soda or lime-gypsum softening reduces alkalinity to the 40-50 ppm range—mainly in the carbonate form. Using hot lime-hot zeolite reduces CO_2 further by minimizing alkalinity of the softener effluent. Reducing alkalinity to the 20-30 ppm range is common practice.

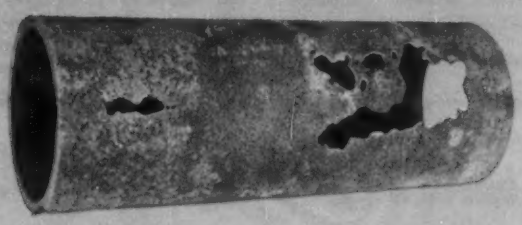
Systems that operate "cold" and that can reduce or virtually eliminate carbon dioxide are (1) sodium zeolite, followed by acidification, degasification and neutralization (2) acid zeolite followed by neutralization (3) split-stream combination of sodium and acid zeolites followed by degasification (4) sodium zeolite-chloride, commonly called dealkalization, and (5) demineralization, with degasifier between acid and basic-ion exchangers.

You can, by choosing the right external treatment process, bring CO_2 down to about 5 ppm or less. At this level corrosion generally won't be serious. But before you get too wrapped

INSIDE BOILER DRUM view shows formation of oxygen pits. Corrosion is likely where circulation is sluggish

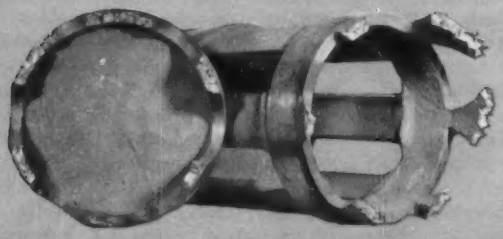


INTERCRYSTALLINE CRACKING of boiler drum section is due to uncontrolled caustic soda in feedwater



GENERAL THINNING of condensate line can eventually eat through pipe. Carbon dioxide was culprit here too

ANOTHER WAY to spot carbon dioxide grooving attack: it's invariably on bottom of pipe where water digs in



STRESS CORROSION cracking caused feedwater regulator failure. Changing heat treatment solved problem

TOO MUCH MOISTURE at turbine's low-pressure end caused combined erosion and corrosion of the blading

what it looks like . . . what you can do about it

up in removing the last traces of residual CO_2 take a good look at the economics. Extreme refinements in external treatment may not be justified, especially if you plan to team it up with internal treatments — injecting amines directly to the boiler for example. Many of the inhibitors we talked about on page 92 apply to CO_2 control.

Another approach to licking the CO_2 problem and condensate-system corrosion in general: Backing up good chemical treatment with right choice of piping material. The Code for Pressure Piping, published by The American Society of Mechanical Engineers is an excellent guide.

Swinging over now to steam-generating equipment, corrosion and pitting usually mean that low pH and dissolved oxygen have been at work. Sodium sulfite is the reducing agent that's generally favored to remove oxygen in the boiler because it's low cost, easy to handle, and doesn't form scale. Other chemicals—organic colloids, hydrazine—can also do a good job. (See page 90 for more info on pH, oxygen).

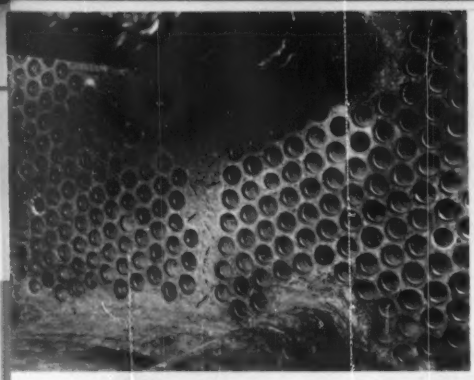
Recirculating boiler water—about 1 or 2%—and returning it to the boiler-feed line — either before or after the boiler-feed pump — boosts alkalinity, provides an added measure of protection against corrosion. It's often used on low-makeup systems.

Intergranular corrosion, also called intercrystalline cracking or caustic embrittlement, attacks welded-drum boilers at rolled-in tube ends. On riveted construction, seams are a likely weak spot. Engineers tag this corrosion form caustic embrittlement because sodium hydroxide (caustic soda) in boiler water is its chief cause. Also, it appears as a brittle fracture.

Conditions promoting embrittlement are (1) boiler-water leakage (2) high stresses due to cold working of the metal or expansion and contraction (3) water chemically attacking metal. Engineers haven't come up with a cure-all that will handle every embrittlement condition. So licking the problem depends on carefully matching conditions in your boiler to available control methods: pH-phosphate control, sodium nitrate, tannin inhibitors.

pH-phosphate treatment involves simultaneous control of both the pH and phosphate content of boiler water. Sodium nitrate can be fed continuously to boiler feedwater or directly to the boiler drum. Its job is to maintain a definite sodium nitrate, sodium hydroxide ratio that inhibits embrittlement. Tannins also establish a definite tannin-sodium hydroxide ratio.

You can often tell the cause of corrosion in steam and condensate systems by corroded part's appearance. Photos above show common types.



DEZINCIFICATION of a condenser-tube sheet (90-10 copper-tin) on salt water side. Half of sheet thickness is lost

PITTING CORROSION of cast-iron diesel cylinder liner after only six months service. Salt water was cooling medium

CAVITATION CORROSION of a bronze impeller in this salt-water circulating pump virtually destroyed impeller blades

Cooling system corrosion . . . backing up right metal

Cooling-water corrosion might well be one of your major headaches, regardless of whether you're responsible for air-conditioning, steam-power generation, compressed air, refrigeration, diesels, gas engines or heat-exchange processes.

A variety of factors influence cooling-water corrosion. We've listed the most common ones in the table below. Most important among these are water composition—dissolved oxygen and carbon dioxide, pH and dissolved solids. Temperature, velocity, contact with dissimilar metals (galvanic action) also shape up as key factors in many systems.

Right approach to the problem depends largely on which type of system you have. You can, for example, economically justify more extensive treatment in recirculating systems than in once-through types, largely because of relative water quantities involved. In open systems, effect of toxic inhibitors in windage and spray losses can be dangerous.

Corrosion control in any of these systems starts in the design stage—good mechanical design and choosing the right metals. Many of today's copper-base and aluminum-base alloys ward off corrosion in heat exchangers and condensers.

From an operations and maintenance viewpoint, corrosion control boils down to chemical treatment, cathodic protection and protective coatings.

In once-through systems you can get protection by building up a film of calcium-carbonate scale. Common chemicals for this purpose are soda ash, caustic soda and lime (calcium hydroxide). Lime is usually the lowest-cost method because it raises the calcium content as well as alkalinity and pH, thus creating right conditions for scale buildup. Major drawback to this technique where heat transfer is involved: Difficulty in controlling scale thickness so that you get overall protection without materially interfering with heat transfer.

Removing dissolved oxygen itself, attacks the problem more directly. Mechanical deaerating methods like vacuum deaeration do a good job. But relatively high investment and operating costs limit its use.

Chemical deaeration with sodium sulfite works well at higher temperatures. But at common cooling-water temperatures the reaction between sulfite and oxygen is slow. Recent development of catalysts to speed the reaction now make chemical deaeration practical.

Corrosion inhibitors most widely employed in industrial cooling-water systems are the chromates, polyphosphates, silicates, nitrites and dianodic combinations of phosphates and chromates (a combination of two anodic inhibitors that

Factors controlling corrosion . . .

Impingement corrosion

Alloy composition
Water composition
Velocity of water
Sand, marine organisms, gases
Partial obstructions in tubes
Galvanic
Temperature
Vibration
Design, depth of water boxes, radius of bends, etc.

Pitting

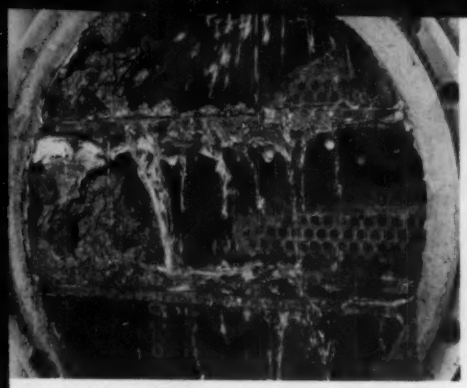
Alloy composition
Water composition
Lack of cleaning (deposits)
Temperature
Sand, silt, muck, marine organisms (deposits)
Surface films
Galvanic
Velocity of water
Vibration

Cracking

Alloy composition
Creep, temperature
Corrosion fissuring
Stress (residual, static, thermal)
Vibration-fatigue
Corrosion fatigue
Shock
Design
Internal flaws
Slimes

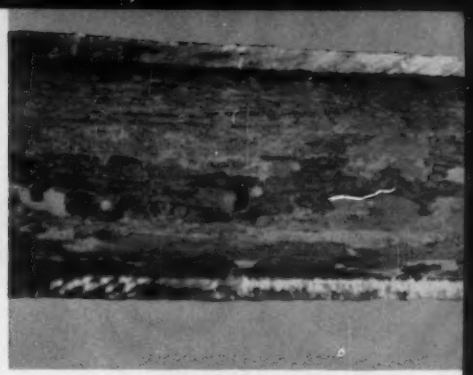
Thinning or general corrosion

Alloy composition
Water composition
Velocity
Sand, silt, muck, marine organisms
Temperature



SLIME TEAMED UP with calcium carbonate scale and corrosion products in this aftercooler waterbox to clog system

CORROSION FATIGUE crack in a vibrating aluminum-brass condenser tube. Engine vibrations supplied fatigue effect



IMPINGEMENT CORROSION of admiralty condenser tube is due to entrained air (oxygen) in water, destroying film

with chemical treatment satisfies most needs

produce better results than either used alone). Also showing strong promise are many of the organic inhibitors.

As you might expect, biggest problem with the once-through systems is cost. For this reason, corrosion inhibitors are fed only in sufficient quantity to control severe corrosion. It's the rare once-through system that uses sufficient inhibitor to completely stifle corrosive attack.

Open-recirculating-system corrosion can be even more difficult to cope with than corrosion headaches in once-through systems. Intimate contact of the cooling water with air as it passes over the cooling tower or through spray ponds, continuously saturates it with dissolved oxygen. Towers in industrial areas may also be contaminated with sulfur dioxide, ammonia, hydrogen sulfide. And the buildup of dissolved solids—chlorides, sulfates, etc.—as the system cycles, adds to corrosion.

Closed systems. For ease of corrosion control, closed systems hold a big edge over other types. Cycling doesn't tend to concentrate dissolved solids. Water doesn't continuously contact the oxygen-laden atmosphere. And system is generally free of "open-system" headaches.

Closed systems make economical use of inhibitors because they lose relatively little water. Thus, chromates are used extensively. But chromates aren't compatible with ethylene glycol anti-freeze solutions. These solutions normally incorporate organic inhibitors.

Closed cooling-water systems almost always get the nod for diesel and natural-gas-engine cooling, and for chilled-water air-conditioning systems.

Cathodic protection is a strong contender for guarding once-through systems that face highly concentrated corrosion problems. Where sea water or brackish water passes through condenser circulating-water systems that include steel or cast-iron water boxes and copper alloy tubes and tube sheets, powerful galvanic corrosion cells are likely to exist. Result: Deep pitting of steel water boxes and graphitic corrosion of cast-iron water boxes. A well-designed cathodic protection system can choke off these effects. Protective anodes — often zinc, magnesium or aluminum — are mounted in the water box or on the water-box cover.

Synthetic-resin-base coatings we talked about, pp 86-87, can stand up underwater for long periods of time. Thus, they're used to back up cathodic protection by covering water-box sides and cover as well as tube sheets and tube ends. These protective barriers reduce the required number of anodes as well as stretch anode life substantially.

. . . in cooling-water systems

Intergranular

Alloy composition
Water composition
Low velocity
Temperature
Stress
Design
Scale or slime

Dezincification

Alloy composition
Water composition
Temperature
Low velocity
Salt, sand, etc.

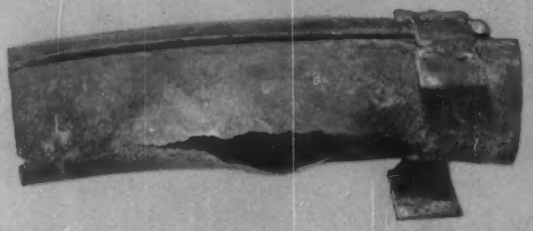
Corrosion in refrigeration systems

Brines are generally conceded to be chief offenders when it comes to refrigerating-system corrosion. They're strong solutions of calcium or sodium chloride. Because of its low freezing point, calcium brine gets the nod most often.

Corrosion rate depends on type of brine, extent of magnesium-chloride contamination, pH, contacting metals and brine density.

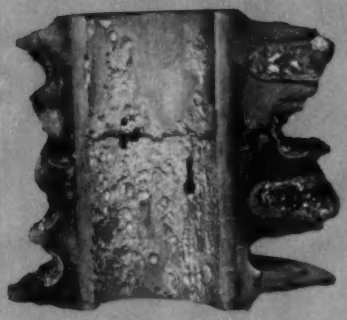
Corrosion committee of the American Society of Refrigeration Engineers makes these recommendations: (1) For calcium brines — 100 pounds sodium dichromate per 1000 cu ft of brine. Also, enough sodium hydroxide (caustic soda) to convert dichromate to neutral chromate. (2) For sodium brines — 200 pounds of sodium dichromate per 1000 cu ft. Add caustic soda here too. And for best results renew dichromate semi-annually.

METAL WASTAGE on this diesel-engine piston head resulted from harmful impurities in residual fuel oil

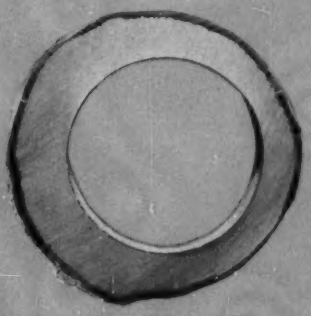


CREVICE CORROSION resulted from collection of flyash in annular space between boiler tube and protective pad

VANADIUM ATTACK, from vanadium in fuel oil, corroded this superheater hanger. Overheating also contributed



STRESS CORROSION of finned economizer tube due to local bending stress



HIGH-TEMP OXIDATION resulted from overheating this superheater tube. Abrupt change in scale thickness is spalling

Combustion...it presents *low*- as well as

We've already seen how temperature affects corrosion, p 91. What happens if we allow temperatures to soar well over 1000 F and compound the problem with the corrosive effects of combustion gases and their condensation products? What steps can we take to avert possible consequences?

Best approach to controlling-combustion-products corrosion is the two-pronged attack stressed throughout this report: Improving metal's resistance to corrosion and taming the corrodent.

High-temperature oxidation corrosion generally makes its presence felt by alternate scaling, spalling of oxide layers; *see sketches, facing page.* But if conditions are right for scale buildup, corrosion drops off rapidly as scale thickness grows. Also, oxidation increases as temperature climbs. And rate of increase is greater at higher temperatures.

High-temperature oxidation can occur in pure air or oxygen. But from a practical viewpoint we need to look at it along with a variety of factors that tend to complicate the picture. The presence of moisture or carbon dioxide speeds oxidation. And the effect is more pronounced at higher temperatures. Sulfur dioxide, common component of furnace gas, boosts scaling rate and can bring on deep intergranular corrosion. But, surprisingly, excess free oxygen in the furnace atmosphere tends to nullify the intergranular effect on steels.

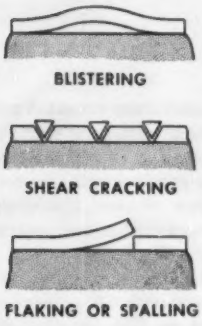
Velocity too plays a key role in determining nature of the scale. Scaling, spalling become more intense at higher gas speeds. But *rate* of increase dips and eventually levels off as velocity climbs.

We've already seen how changing the gas atmosphere (supplying excess oxygen) can reduce high-temperature corrosion. Another technique along similar lines: Increasing ratio of carbon monoxide to carbon dioxide in combustion gas. Drawback of this method: It cuts into combustion efficiency. Better way is to boost metal's corrosion resistance.

Boiler, internal-combustion engine and gas-turbine manufacturers are well aware of problems associated with combustion-products corrosion. And part of their first line of defense are today's corrosion-resistant metals. Adding alloying elements—chromium, nickel, silicon, aluminum—to steel, see pp 82-83, goes a long way toward heading off the corrosion problem before it has a chance to start. Widely used ferrous alloys that resist high-temperature oxidation are the high-chromium irons, chrome-nickel irons and austenitic chrome-nickel steels. Superheater steels contain varying amounts of chromium, molybdenum.

Sulfur, vanadium, alkali ash and sodium in fuels can be a major headache because they form a low-melting

How oxide scales break down



Among factors influencing resistance to high-temperature oxidation, physical characteristics of scale share top importance.

Blistering may occur in oxide layers having good elasticity but poor adherence to the metal surface.

Shear cracking on the other hand will be found in oxides that are adherent but brittle.

Flaking or spalling results when the oxide is both brittle and non-adherent.

As the scale peels away it exposes a fresh area to further attack. And loss of the oxide causes progressive thinning, ultimate failure of the metal.

HIGH-TEMPERATURE WORK SHEET

CORROSION FACTORS

1. **PROCESS OR OPERATION:** (e.g., heat treating, vitreous enameling, hydrocarbon reactions, etc.) _____
2. **HEATING PRACTICE:** Analysis of fuel _____ Temperature °F. or °C. Maximum _____ Average _____ Standby _____ Time at temperature _____ Rate of heating _____ Method of cooling (e.g. furnace cool, oil quench, etc.) _____ Frequency of heating and cooling _____ Magnitude of operating stress _____ Type of stress (e.g., static, fatigue, impact, etc.) _____
3. **ENVIRONMENT:** Chemical composition of atmosphere, fused salt, molten metal, etc. in contact with metal surface _____ In the case of an atmosphere, give dew point _____ Concentration of sulfur compounds, if any, preferably in grains sulfur per 100 cu. ft. of gas _____

EQUIPMENT

4. **EQUIPMENT OR PART:** (e.g., radiant tube, lead pot, gas-cracking tube, etc.) _____
5. **METAL OR ALLOY OR OTHER MATERIAL USED:** (e.g., composition, and type number or trade name, wrought or cast) _____
6. **DIMENSIONS:** Size and thickness of rod, sheet, plate or tubing used, or dimensions of casting _____

EXPERIENCE

7. **SERVICE LIFE OF MATERIAL USED:** _____
8. **TYPE OF FAILURE:** (e.g., cracking, sagging, general scaling, local attack, embrittlement, etc.) _____

SIMPLIFIED FORM—high-temperature work sheet—is filled out and returned to corrosion-resistant-metals producer who supplies data, helps you choose right metal

high-temperature corrosion problems

point slag which is extremely corrosive to metals and alloys above 1200 F.

Treating Bunker C oil, for instance, to remove one or more of these impurities, or using additives to raise slag's melting point are possible cures.

Diesels. If cylinder-wall temperatures are above the dew point, sulfuric acid doesn't form (from combustion products of sulfur-bearing fuels). Thus there's little likelihood of corrosion. But light-load operation drops temperature, makes sulfuric acid formation easier. And ash content of the fuel as well as poor combustion conditions can, if you allow them to go unchecked, contribute heavily to corrosion, wear.

If a boiler is afflicted with high-temperature oxidation it generally shows up on external surfaces of tubes exposed to radiant heat. Metal surface is rough and looks flat.

In lower temperature sections—air heaters, economizers, stacks—of boiler combustion-gas systems, requirement of low flue-gas temperature for high boiler efficiencies comes in conflict with the corrosion problem. When a high-vanadium fuel burns at temperature that melts the ash combustion products, vanadium ash deposits as a corrosive dense-slag residue. Also, vanadium acting as a catalyst promotes formation of sulfur trioxide from sulfur dioxide. Result: Corrosive sulfuric acid when combustion gases dip below their dew-point temperature.

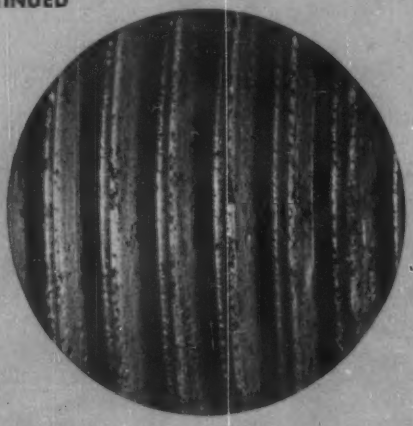
Today's boiler designers lick the problem via several routes. They determine and stay within minimum allowable tube-metal temperatures in designing air heaters, economizers. In pinning down these temperatures they take into account type of fuel burned, firing method.

Corrosion-resistant steels are often teamed up with flue, duct and stack linings made of corrosion-resistant concretes and refractories. Also, glass-lined stacks, p 89, are beginning to enter the picture.

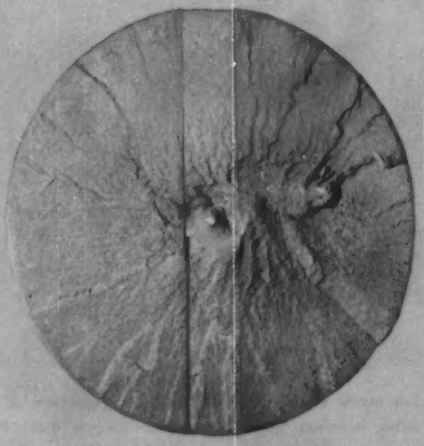
Advent of fuel additives in recent years to retard combustion corrosion has produced some good results. But you'll do well to exercise extreme care in their use. An additive that does a good job under one set of conditions may be completely ineffective under conditions that *seem* to vary only slightly. Where sulfur acids cause trouble, additives are generally alkaline compounds. Aluminum and silicon compounds are often favored to cope with sodium, vanadium in fuel.

When firing vanadium-bearing fuels it's possible to get a soft ash that's more readily removable and less corrosive than hard slag deposits that can form in superheater regions. Additives of aluminum, calcium and magnesium oxides yield these results.

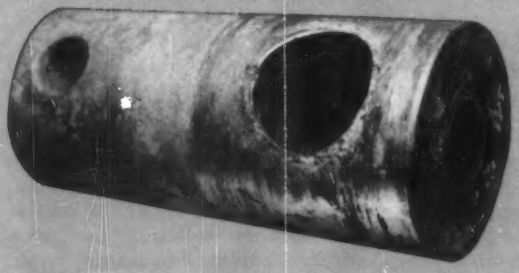
Some additives — kaolin, dolomite, magnesia — are injected directly into combustion chambers.



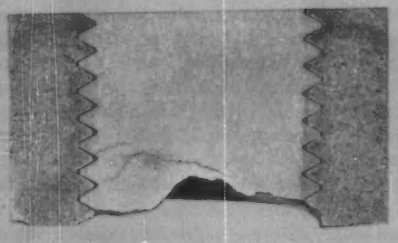
STUD BOLT from turbine casing failed due to stress-corrosion cracking. Cracks reduced effective bolt area



PUMP SHAFT lost about ⅝-in. diameter due to uniform corrosion. Then fatigue cracks promoted fracture



PLUG from 1-in. plug valve shows effects of impingement corrosion attack along edge of the plug's opening



BOLT from turbine's dummy cylinder was tightened too much, causing high stress that teamed with corrosion

Machinery, structures . . .

Not too many years have passed since accepted practice was simply to beef up machine and structural parts enough so that even with severe corrosion there was little possibility of failure. We recognize such practice today as an approach that sidesteps the *real* problem. Present thinking is to *corrosion-engineer* machinery and structures as an integral part of good mechanical design.

Most common corrodent of above-ground structures is the atmosphere. Its effects vary with the seasons, geographical areas, extent of air pollution. But entrained moisture in the atmosphere overrides all other factors. Sulfur dioxide, hydrogen sulfide and other contaminants corrode metal much faster in moist air than in dry.

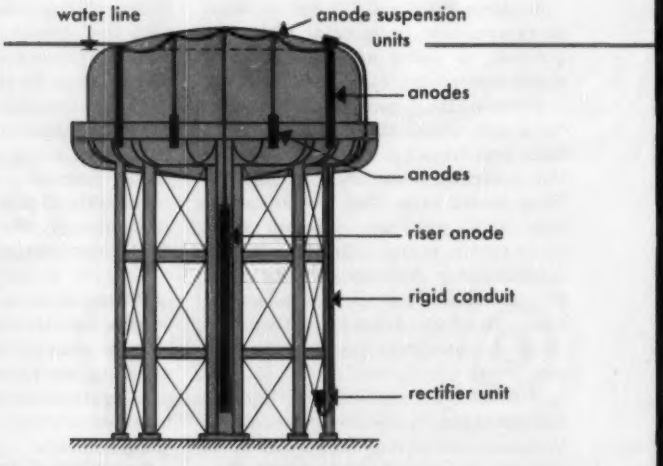
Chemicals used in industrial processes attack machine and structural members. But metallurgists have come up with metals that are formulated to handle even highly corrosive chemicals, pp 82-83. And many effective barriers are tailored to withstand chemical attack, pp 86-89.

Stress. Experts differ on whether static and dynamic stresses *cause* corrosion. Some findings show no cause-effect relation. Others show that stress accelerates corrosion. Some even report an inhibiting effect. But, clearly, where both stress and corrosion are present, action is a snowballing one that can lead to cracking, ultimate failure of vital machinery and equipment.

Operating temperatures have special importance where you're dealing with corrosion of moving parts. Even small jump in temperature can initiate corrosion in an otherwise smooth-running bearing.

Having pinpointed the possible bad actors we turn our attention to ways of thwarting them. The familiar standbys —metals, inert barriers—are once again our first line of defense. On a tonnage basis, the low-carbon structural steels—not especially conspicuous for their corrosion resistance—are most important. Thus they're almost always teamed with protective coatings, mastics or linings.

In protecting outdoor steel structures with paints, periodic maintenance, inspection and renewal of coatings can stretch



CATHODIC PROTECTION of elevated water storage tank guards tank's inside walls. System anodes are shown oversize

. . . corrosion-engineer them in the blueprint stage

their life span many years. How frequently you renew coatings depends on severity of the atmosphere.

Cathodic protection for the insides of such structures as elevated water-storage tanks, water-treatment tanks, chemical-process vessels, can be economically attractive. But you'll need to check required current density, probable anode life, number of anodes. Size of the installation and solution's tendency to corrode the tank are controlling factors. Unless you're thoroughly familiar with cathodic-protection system design, it'll pay to call in a company specializing in such installations. Sketch, *bottom of facing page*, shows how an electrolytic cathodic protection system is hooked up to protect the inside of a large elevated water-storage tank. Rectifier supplies dc power.

Bearings—because they're load carrying elements and contacting surfaces—are potential weak spots in the anti-corrosion armor of any machine. Bearing metals, operating conditions and lubricants rate a long, hard look before you specify them for your service systems.

Stability of lube oil plays a key role in bearing corrosion. Here's why: If oil doesn't break down, its film-forming ability makes it an excellent corrosion preventive. But if it readily oxidizes (becomes unstable), oxidation products may attack bearing metal. Solvent-extracted paraffinic oils have much stronger corrosion tendencies than the napthenic types. But virtually all of today's lubes give good anti-corrosion performance by blending them with additives.

Stabilizing additives—phosphorous, sulfur, phenolic and aromatic-amine base types—in small concentrations keep oil from breaking down under most bearing service conditions you're likely to encounter.

Bearing metals vary considerably in their corrosion resistance. Older tin-base babbitt bearings are less affected by lube-oil oxidation products than cadmium-base and copper-lead bearings. But copper, cadmium types have greater high-temperature strength. Also, economics often favor the copper base. Lead-indium and lead-tin coatings applied to copper-lead bearings boost their corrosion resistance.

Equipment design. Earlier we said that corrosion-engineering is a part of good mechanical design. Here, in brief, are some of the more common ways to lick machinery and structure corrosion in the *blueprint* stage:

(1) Avoid sharp corners where possible. They act as stress raisers and are likely spots for stress-corrosion cracking. Sharp corners also cause thin spots in protective coatings and linings.

(2) Joining hardware — rivets, bolts, screws — are vulnerable to crevice corrosion. They tend to form concentration cells by starving metal areas of oxygen, page 78. Where you must use them, consider advantages of hardware made from the same metal as parts being joined. You'll steer clear of possible galvanic couples.

(3) Where statically stressed members operate in corrosive atmospheres be sure corrosion can't reduce load-carrying areas to unsafe levels.

(4) Give special attention to vibration conditions where heavily loaded parts such as bearings are press-fit. If such parts slip (due to vibration), fatigue cracks may start. Result: Fretting corrosion, see page 79.

(5) If you can't avoid teaming two metals that may form a galvanic couple, design the anode so that it's large compared to the cathode.

(6) Study the effects of cyclic stresses. Part may be within safe stress limits at first. But corrosion may team up with fatigue effect of stress reversals, bring on eventual failure.

Maintenance cleaning of parts can thwart pitting attack. When corrosion products form over new pits they speed the attack. But if you remove corroded material before pit gets too deep, corrosion is likely to shift to another area. By keeping corrosion uniform over an entire metal area its pitting effect can be materially reduced.

For coal-handling structures:

Coal has three characteristics that make it uncommonly gifted in corroding and eroding its handling equipment: First, sulfur reacting with ever-present moisture forms a weak solution of sulfuric acid. Second, coal is abrasive. As it flows over a rough, corroded surface, wear is intensified. Third, moisture-laden coal fines have a tendency to pack, especially under lot-storage conditions.

One relatively low-cost answer to the problem—stainless-clad steel—has come in for a good bit of attention recently. Here's one case history: At a large eastern utility, carbon-steel chutes had a life expectancy of roughly four years. Corrosion on inside surfaces was responsible for many coal-flow stoppages. The company investigated and installed a stainless-clad hopper and chute. After 9½ years there was no loss of cladding. Only effect of the coal was to polish the clad surface to a shiny finish.

This is corrosion fatigue!

Pinion gear, subject to cyclic loading, initially operated at safe stress levels. But small corrosion pits soon developed as a result of moisture entrained in the lubricant. Pits acted as stress raisers. When local stresses exceeded failure stress of the metal (a chrome-nickel-moly steel), cracking started. At first, crack grew under the impetus of moisture in the lube oil. Later, fatigue took over.

Possible cures: Check lube for moisture, other contaminants. Consider altering metal composition.

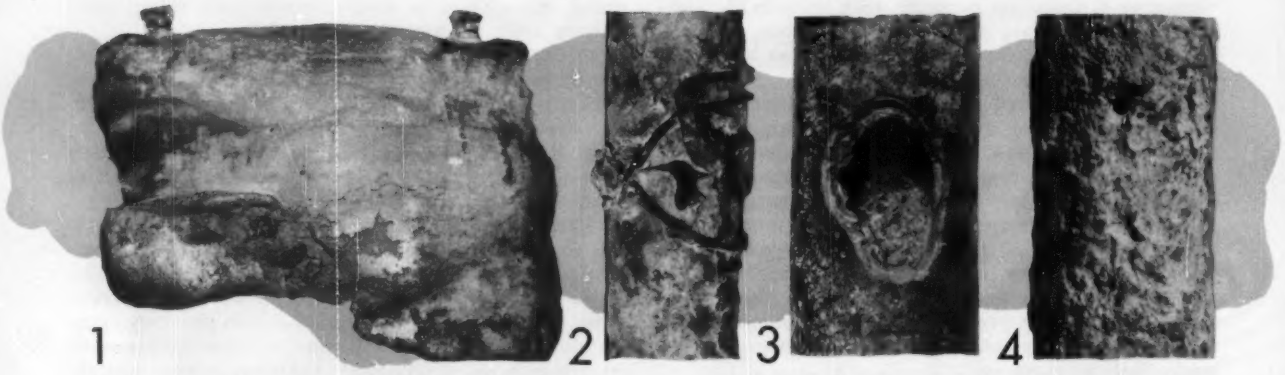
Underground corrosion . . . soils and stray currents

You'd be hard pressed to find any of today's industrial plants without one or more of their key services—electric power, fuel oil, steam, condensate returns, water supply, air, water piping—flowing underground. The cable, piping, tanks and other structures that make up these services can be attacked by many of the familiar corrosion culprits we've talked about thus far. And—making underground corrosion even more complex than corrosion above ground—several new ones enter the picture. Here, in brief, are key items:

By far the most important—from the plant and corrosion engineer's viewpoint—is condition of the soil. It can be corrosive or it can be relatively noncorrosive, depending on a variety of chemical and physical characteristics.

Symptoms of noncorrosive soil are: high pH, low moisture content, sandy structure, little organic matter, light color, high oxygen content, low temperature. In contrast, corrosive soils are generally acid, contain substantial amounts of moisture, clay and organic material, appear

Where your underground systems are vulnerable



1: LEAD CABLE SLEEVE corroded due to free lime in underground concrete. The corrosion product is a lead oxide
2: GALVANIC ACTION at the brass phase tag of this lead-sheathed cable caused corrosion. Insulation tape solved the problem
3: BURIED CAST-IRON water main corroded due to action between cast iron, cinder fill. PD can go has high as 1 volt
4: BURIED LEAD water pipe suffered stray-current corrosion from stray railway currents. Drainage solves problem

What you can do about it

In talking about soils, *top of page*, we said that high resistivity is one mark of a noncorrosive soil. Yet, when it comes to cathodic protection of underground power services we generally try to look for a low-resistivity (1000 ohms per cc or less) soil in which to bury our anode systems (ground beds). Here's the reason: Successful cathodic protection depends on *encouraging* current flow from anode to cathode. And soil is the major factor in circuit resistance. In electrolytic cathodic protection systems, low soil resistance means low power input. In galvanic systems, low soil resistance means more protective current from a given set of anodes.

Choosing a site for ground beds often boils down to comparing differences in power cost or quantity of protective current with differences in installation cost. Thus, you may find a low-resistance soil. But its location (accessibility, distance from plant, etc.) could nullify potential-power and protective-current savings.

A careful economic study will also help you decide between electrolytic (rectifier-type) and galvanic protection. We've seen, page 81, that rectifier protection fits where you need large blocks of current at few locations. Also, ac power must be easy to get. Galvanic types do best where current requirements are low, soil resistivity is low and ac power is hard to come by. But remember: These are only general rules of thumb. You'll have to weigh each situation on its own merits.

The field survey is an important initial step, before committing yourself to a specific cathodic protection system. Most important: You'll need data on soil conditions—moisture, pH, resistivity, density, etc. Buried structure-to-soil potentials are an excellent indication of the protection you need *and* of the effectiveness of your protection system *after* it's installed. Good anti-corrosion practice for buried coated pipe calls for keeping the pipe close to 0.85 volts negative to the ground (when using a copper-copper sulfate ground-reference electrode).

If you have abandoned structures close to equipment you want to protect, they can make an economical ground bed. Many power companies cut protection costs for buried power cables by using scrap rail or pipe buried in the earth, next to the cable duct bank. They apply a positive potential (via a rectifier hookup) to scrap-material anodes and impress a current flow through the earth to the power cables.

are added headaches

dark, hold little oxygen and are relatively warm to the touch.

No one of these earmarks, by itself, establishes the soil as corrosive or noncorrosive. It's the combined effect that counts. And—as you might expect after looking over these symptoms—a soil can become more or less corrosive with seasonal weather changes.

You can get a good indication of what a soil will do to buried metal by measuring soil's electrical resistivity. High-resistivity soils cut down corrosion currents.

The soil survey is important—but

In the present state of the corrosion-combatting art, researchers have yet to devise a single overall index of soil corrosivity. Often, the same soil will have traits that put it in both corrosive and noncorrosive classes.

Tests run by the National Bureau of Standards, attempting to correlate soil corrosivity with other soil properties, showed that noncorrosive soils have high resistivities (several thousand ohms per cc). But they also found that noncorrosive soils could have high or low aeration and high or low acidity. Thus, while soil studies are important, it's even more important to weigh *all* data you get from them. And be sure to double check the validity of such studies by corrosion tests at regular intervals *after* equipment is installed.

What can corrosion do to your underground services? Where is your underground system most vulnerable? You get a not-very-pretty answer to the first question by a glance at the photos, left. Here are some likely answers to the second:

Electric cable sheath. Poor soils aren't the only reason why underground cable sheath corrodes. Nearby metal structures can be cathodic to lead cable sheaths, cause stray corrosion currents to flow. Fortunately, lead sheath is close (in the galvanic series) to steel and iron pipes. But, if conditions are right, you can set up a strong galvanic couple. In the past, street railways were a principal source of stray current largely because of their relatively low rail-to-earth resistance.

Copper-clad ground rods and copper grounding cables have been the cause of many a lead-covered-cable failure at generating and substations. With lead sheaths solidly interconnected to bare copper, lead will corrode, fail—especially if soil and cable duct resistance are low. One practical solution: Jacketed cable.

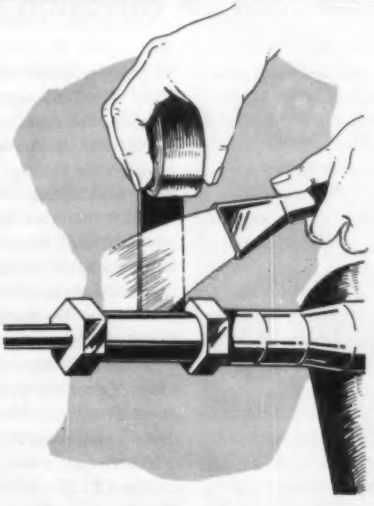
Your plant's grounding system itself can be knocked out by corrosion if you don't provide it with adequate protection. Steel grounding rods and connecting grounding buses may be anodic to nearby buried structures. Or, differences in soil pressure, stretches of wet soil followed by dry soil, scratches, breaks and abrasion of grounding components may combine to set up local corrosion cells between different areas *within* your grounding system.

Buried piping is subject to much the same corrosion conditions as sheathed cable. When we bury pipe, we set up many local anode and cathode areas on it. Here's why: (1) Different sections of the pipe may be contacting soils of different chemical, physical traits. (2) Newly buried pipe is generally anodic to old pipe connected to it. (3) Soil aeration may be different at various points in contact with the pipe.

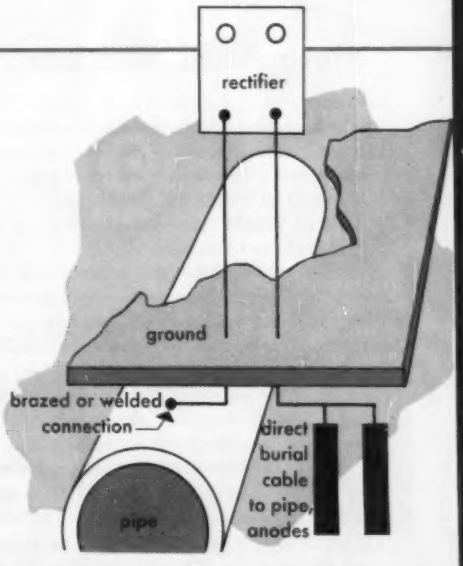
Galvanic cells due to nearby structures also cause buried pipe to corrode.

Electrolysis drainage (electrolysis refers to action of current on the anode) is a practical, low-cost way to tame stray-current corrosion. These currents can come from electric railway systems having rails poorly insulated from the earth, electric welding units, cathodic protection systems, electroplating plants, etc. The buried metallic structure that corrodes acts as a low-resistance path and tends to collect these stray currents. The drainage system simply makes an electrical connection between the buried metal (cable sheath for instance) and the negative feeder of the source of stray current.

Protective coating and jacketing, pp 86-87, are often the first line of defense for underground piping, cables. These inert barriers are lower cost and generally easier to justify economically on smaller buried structures.



RESIST CORROSIVE SOILS by coating and wrapping underground pipe-systems with hot-applied coatings and asbestos felt



RECTIFIER-TYPE cathodic protection for underground pipes, cables, fits if you need large currents at a few points

CORROSION TESTS... they supply vital data for your important corrosion-control decisions

Behind every successful corrosion-control program you'll find a solid foundation of reliable information. The info-gathering operation begins in the early program planning stages and never actually ends. Even after corrosion-control efforts have become relatively routine, keeping close tabs on their effectiveness pays off.

Broadly speaking, corrosion testing divides into (1) lab tests and (2) in-plant and field tests. Here we concern ourselves mainly with the latter because plant and power-service men find greater occasion for actually running such tests. But it's important to recognize that lab testing facilities are available to even small companies. Corrosion-resistant materials producers and corrosion consultants, are staffed with specialists that run lab tests on corrosion samples which are sent in after being exposed to plant and field conditions. Also, the results of lab tests run by such organizations as The National Bureau of Standards and by members of The National Association of Corrosion Engineers are available in handbooks, engineering society technical papers, etc. Such data are an important source of practical information for engineers concerned with corrosion control and related problems.

Plant and field tests generally break down into direct observation, mechanical, chemical and electrochemical, and electrical. Chances are, you won't be running all of them in your plant. Soil corrosion, for instance, is mainly checked by electrical, chemical tests. Water corrosion data stems largely from chemical tests. Atmospheric corrosion—especially where protective coatings are used—is often a matter of visual inspection or photographic methods.

Direct observation is simple, fast, but has several drawbacks

The chief advantage of direct-observation tests are their simplicity. But, unless you supplement them with more exact techniques, they have some serious drawbacks. You can't use them until *after* equipment that's likely to corrode is actually installed. And used alone, they can be *too little* and *too late*. *Accidental* direct observation is too often the only form of corrosion control in operation. Yet, once you recognize the limitations of these visual tests they can become a valuable asset to your corrosion-control program.

If you're responsible for visual tests, be sure plant men can write brief but accurate descriptions of corrosion conditions they see. It's important, for instance that "severe corrosion" means the same thing to everyone responsible for visual checks. Class-room writing sessions with operating men are a big help in boosting test efficiency.

Photography is a first-class tool for showing the progress of corrosion—or lack of it. Often, color photos help you spot different types of corrosion product at a glance.

Another visual technique that's sometimes helpful but not always easy to run: plaster casts of corroded parts.

Continual direct observation is of key importance wherever you've applied inert barriers. By alerting plant operators (who aren't necessarily responsible for corrosion problems) to watch for breaks in coatings, mastics, linings on equipment they operate, you'll get better results from inert barrier protection—and at no extra cost.

Mechanical tests keep close tabs on corrosion rate

Mechanical tests, as we view them here, include (1) dimensional measurements. For example, measuring depth of corrosion pits. (2) Gain-in-weight tests. They're useful where it's easy to weigh the metal plus its corrosion product. (3) Loss-in-weight tests—where corrosion products break loose and are easy to remove.

The micrometer pit gage yields valuable info on the extent of pitting corrosion. By measuring extent of pitting at regular time intervals you can plot a time-depth curve that can be an excellent guide for estimating corrosion rates, expected life of equipment. Important: Don't forget to keep an accurate record of the location of each pit you're "tracking." And be sure to take into account the distribution of pitting in interpreting your results.

Electrical instruments that read directly in micro-inches of corrosion consist essentially of a metal test element exposed to corrosive conditions. The element is part of an electric circuit on which change-in-resistance measurements are made as the test element corrodes and reduces in cross-section. (Note: Since the instrument reads directly in mechanical units, we classify it as a mechanical test.)

Earlier, pp 86-87, we said that film thickness is crucial in getting good results from protective coatings. Thus, we need reliable ways of measuring films. Simplest method is micrometer measurement. By gaging several sections of the equipment before and after coatings are applied you can be reasonably sure of staying within protective-coating manufacturer's recommendations.

More complex thickness-measuring devices include needle penetration (an electrical circuit picks up contact with the base metal), change-in-magnetic-force and change-in-inductance measurements.

Change-in-weight tests—either gain or loss—are relatively simple, easy to run. But they're subject to a variety of errors: Moisture content of the corrosion product may vary. You may not remove all corrosion product. And test doesn't tell whether the attack is concentrated or evenly distributed over the metal's surface.

Weight tests are generally run on standard metal samples exposed to the corrosive atmosphere. ASTM recommendations are available for test specimens as well as specimen holders. Samples are weighed on an analytical balance.

Physical properties tests—tensile strength, etc.—before and after corrosion are also highly useful.

Chemical and electrochemical tests for the in-plant lab

Chemical testing—especially the complete chemical analysis of corrosion products, soils, waters—is often a lab affair. But resulting data are highly useful.

For steam- and water-system corrosion there are several simple in-plant lab tests that keep tabs on corrosion.

Common alkalinity test is based on a titration with sulfuric acid. (Note: Standard acid solutions are often used to measure the concentration of alkaline solutions. The acid is added, drop by drop, to the alkaline solution until the neutral or end point is reached as shown by the color change of an indicator such as phenolphthalein or methyl orange. We call this process titration.)

pH is a measure of the effective rather than the total alkalinity of a solution. Index of pH is a number between 0 and 14. At pH of 7, solution is neutral. pH above 7 is increasingly alkaline. pH below 7 is increasingly acid.

The colorometric test for pH depends on the color reactions of different chemical indicators. Each indicator in a test set covers a different pH range.

The electrometric pH meter measures voltage across two electrodes in contact with the solution. Voltage of one electrode is fixed. Second electrode's voltage varies with solution pH. The pH meter is usually faster than color tests.

Free mineral acidity is due to strong acids—sulfuric, nitric and hydrochloric—in water.

You can test for free mineral acidity by titrating sample water with a standard sodium carbonate solution in the presence of methyl orange indicator.

Test for free carbon dioxide is by titration of the sample water with a standard sodium carbonate solution in the presence of phenolphthalein.

Test for dissolved oxygen by the Winkler method also involves titration. Oxygen in water reacts with manganous hydroxide to form manganese hydroxide. Following a reaction with sulfuric acid, solution releases free iodine in proportion to the amount of oxygen absorbed. Free iodine is then titrated in the presence of a starch indicator. The disappearance of blue color signals the end point.

Electrical tests for voltage, current, resistivity

For potential measurements be sure the internal resistance of the instrument you use is very high compared to resistance of leads, electrodes, and resistance to earth of reference electrodes.

Briefly, common potential measurements and instruments that fit are: (1) Rectifier potentials. Where you're installing impressed-current cathodic protection, any voltmeter with required range will work. (2) Structure-to-structure potentials. Often, buried structures are big and have low resistance. Thus, either a low- or high-resistance millivoltmeter or potentiometer does the job. The potentiometer, *right*, features a calibrated dial with a standard cell for calibration. (3) Structure-to-earth potentials. Either galvanic potentials or potentials due to stray currents can be handled with a high-resistance voltmeter. (4) Open-circuit structure-to-anode potential. Either low- or high-resistance voltmeters are usually OK. But if the structure is well-coated pipe or cable with a high resistance to earth, the high-resistance (50,000 to 500,000 ohms per volt) meter is your best bet. (5) Voltage-drop measurements on a structure tell the amount and direction of current flow. Thus, they can show up galvanic corrosion. Generally, low-range millivoltmeters get the nod.

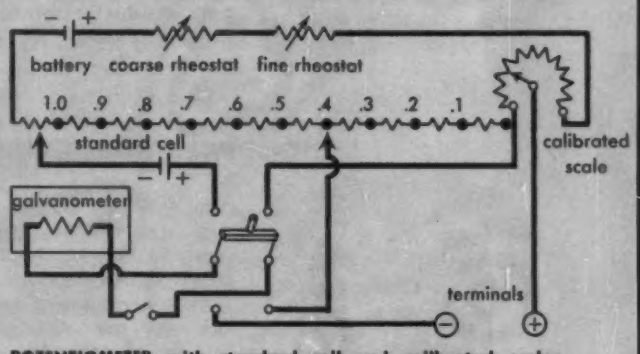
Current measuring instruments — milliammeters and ammeters—self-contained or with external shunts, measure the wide range of currents you'll encounter in field testing. If the external circuit resistance is very low, meter's internal resistance may cause substantial error. One practical answer: the zero-resistance-type ammeter.

Common measurements are: rectifier current, electrolysis drainage current, galvanic current between structures.

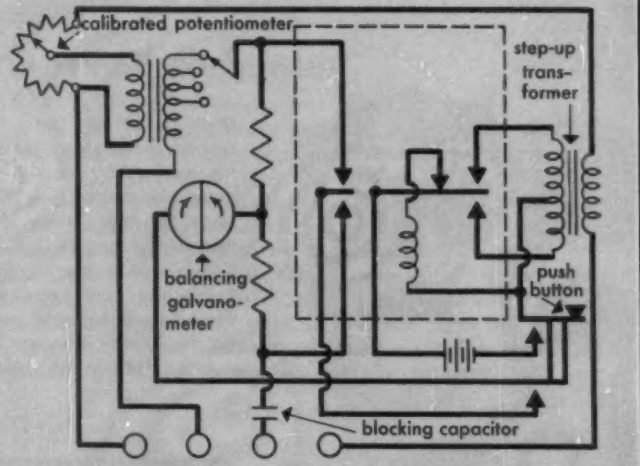
Resistivity instruments can tell you, in advance, how much trouble to expect from underground soil corrosion. They measure the resistivity of the undisturbed soil. Or, they can measure a soil sample in the lab.

The 4-terminal method uses two potential and two current terminals, *drawing at left*. Same instrument measures anode and circuit resistance.

Two-terminal instruments, or two terminals combined in a single rod measure soil resistivity to shallower depths.



POTENTIOMETER with standard cell and calibrated scales can be used for a variety of field potential measurements



RESISTIVITY METER has two current, two potential terminals. It measures soil, circuit and anode resistances

PLANNING FOR CORROSION CONTROL . . . start

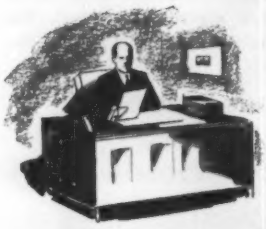
You're plant engineer for the XYZ manufacturing company. Your major responsibilities are the power and plant services. Capital tied up in equipment for these services represent a substantial part of the total plant investment. So—facing facts—you try to protect the investment by organizing a corrosion-control program.

To complicate the picture you're saddled with responsibility for controlling corrosion of production equipment.

Where do you start? What likely administrative problems must you handle? How do you make sure you're getting the most for your money? Who can you turn to for assistance? These—and many more—are questions that doubtless will come up.

Before digging for answers that will help to put you on

Figure your annual bill for corrosion



Finding out your annual bill for corrosion isn't easy, especially if you're just setting up a new plant. But corrosion info on similar plants may be available through the professional societies, consultants, technical publications, etc. In any case it'll pay to check your figures against those of a similar plant.

First step: Review maintenance records for all equipment. Find out where down time was due to corrosion. And be sure to include the cost of lost production.

Next, study past plant equipment budgets. Where equipment has been replaced before its expected life span, find out from maintenance, salvage records whether corrosion played a significant role.

Where corrosion is clearly the cause of shortened equipment life, get present-day costs of the equipment and figure out how much premature scrapping of equipment is costing your plant.

The safety hazard that corrosion represents is an intangible cost.

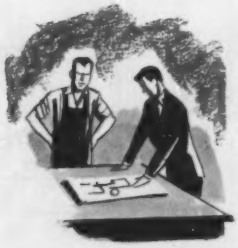
Sell management on protection economics

Armed with the facts and figures your next step is to sell management on corrosion control. You should be able to tell them expected savings for every dollar they invest.

Alert management men need to know how much over-all life of equipment will be extended if they OK your proposals. By citing the cost of future replacement, reconditioning, lost production, wasted manhours, chances are you'll come up with impressive potential savings.

Make sure your report is brief, complete. Avoid going into lengthy discussions of fine points, but be prepared to back up your broad economic conclusions with detailed engineering info.

Talk it over with plant operators



Once you've sold top management on protection economics, chat with plant operating men about your plans. The more they know about what you're trying to accomplish, the more likely are your program's chances for success. What's more they may be able to give you much valuable information, help you avoid pitfalls. And don't forget: In many cases you'll be talking to the men who will actually carry out your program in the plant.

Running informal classroom sessions with plant men on the value of good corrosion control pays big dividends. Some companies even make use of demonstrations showing the corrosion cell in action, measure its corrosion current and potential, page 76. It's a vivid way of making plant operators *corrosion conscious*.

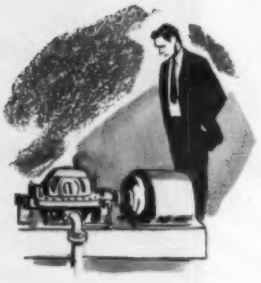
Pointing up the safety hazards of corroding equipment hits home with everyone—management and operating men alike.

by lining up the facts, selling management and operating men

the right track, first decide whether your plant's corrosion problem requires the services of a full-time corrosion engineer and staff. Or, should you—with the help of outside consultants and advice from equipment suppliers—carry the ball yourself?

Size of plant, nature of its operations, extent of power services are items you and your top management will need to weigh. But regardless of which approach gets the nod, be sure you've taken a close look at all the factors. And remember: The small as well as the big plant can profit by enlisting the help of an outside consultant in making a survey of overall anticorrosion needs.

In the sections below we talk about essentials of a six-point approach to practical corrosion control.



Take a close look at maintenance practices

One of the important initial steps in getting your corrosion-control program *on the road* is a top-to-bottom review of plant and equipment maintenance practices.

You know that different metals in contact can—if conditions are right—lead to galvanic corrosion. But do your maintenance procedures recognize this fact? Do they, for example, call for insulation of cast iron mains from copper services—especially on buried systems?

Are your protective coating maintenance programs sound? Do you check to see that coating thickness follows manufacturer's specs? Are you carefully coating steel mains but neglecting cast iron or brass valves connected to these mains? If so, you're not getting full mileage from your coating maintenance program.

By carefully mulling over your maintenance standards you may find many corrosion loopholes such as those we've just cited. Plugging them is often a simple matter. And it pays off handsomely.

Consider the advantages of consultants

Corrosion engineering, by its nature, is a compilation of specialized and complex areas — metallurgy, electricity, chemistry. It's not likely that the plant engineer or even a single corrosion engineer is thoroughly versed in all of its facets. Thus, a group of consultants can be well worth their fee. Here's how you can use them: (1) In the formative stages of direction, training and guidance of a full time corrosion engineering staff. (2) Where extent of the need doesn't warrant a full-time corrosion specialist. (3) Where specialized highly-technical problems come up that can't be tackled by the in-plant staff. (4) To make overall corrosion surveys.

Decide on men, records and equipment

Your anti-corrosion program can be no better than the men who run it, the records they keep, the equipment they use.

In choosing a corrosion engineer, remember: He'll be making decisions that will be responsible for spending thousands of dollars. So judgement errors on his part are likely to be costly. Thus, his technical background, personality should be on a par with top-level engineers in your plant.

Corrosion records—or lack of them—can make or break any corrosion-control program. They're needed to make intelligent estimates. They pin down causes of corrosion trouble. And they eliminate committing important info to memory.

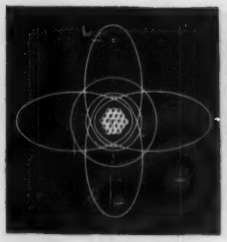
Your anti-corrosion arsenal needs good equipment—instruments, inert barrier materials, chemicals, etc. Once your corrosion men get to know all available types they'll be in a position to choose equipment that meets the special needs of your plant.

Is your company needlessly paying part of industry's multi-billion dollar annual bill for corrosion? Here's a check list to help you find out.

- Do you assign a man (whether his title is Plant Engineer, Power-Service Engineer, Corrosion Engineer, Metallurgist or Maintenance Engineer) to be specifically responsible for corrosion control in your plant?
- Do you know that in many plants maintenance workers (often busy curing corrosion headaches) now outnumber production workers and that this trend is increasing rapidly?
- Are you aware that new materials and techniques can prevent types of corrosion which were previously regarded as inevitable?
- Is your budget for corrosion control in line with today's costs for construction materials, labor and equipment?
- Do you know that it's possible to save several times your Corrosion Engineer's salary by making full use of his services and recommendations?
- Does your design department consult the Corrosion Engineer when it plans new construction projects?
- Does your purchasing department make full use of the Corrosion Engineer's technical know-how when it buys new materials, equipment?
- Are you aware that forward-looking companies—by the application of modern methods of corrosion control—have actually been able to reduce the selling price of their products, thereby gaining a competitive advantage?
- Do you take full advantage of the services offered by corrosion-engineering consultants and manufacturers (metals and inert barrier producers, cathodic protection specialists, etc.)?
- Have you—recently—reviewed the efforts of your company to improve corrosion maintenance practices and to reduce avoidable waste?

ACKNOWLEDGEMENT

Power is indebted to the many producers of corrosion-combatting materials and equipment, consulting engineers, professional societies and trade associations. They have generously supplied technical data as well as helpful advice and criticism in the preparation of this report.



Nuclear notes

By B G A SKROTZKI, *Associate Editor*

Kickoff for nuclear-powered merchant ship was given by AEC approval of Babcock and Wilcox proposal (to design, build, test an atomic reactor plant) as a basis for contract negotiations. The ship will be built under contract to the Maritime Administration of the Department of Commerce. Pressurized-water reactor of advanced design will develop 20,000 shaft hp, should be completed in 39 months. Reactor will be unclassified; new technology developed will be open to American industry.

About 150 fellowships in nuclear-energy technology have been established by AEC. Each carries a stipend of $1800 plus tuition and dependency allowances. They will be awarded to students registered, or accepted by colleges having courses of graduate study in nuclear energy comparable to those given in Commission schools. Applications will be processed before March, 1957.

New data for sodium-deuterium reactor, planned for Chugach Electric Association, Anchorage, Alaska, was recently revealed by Nuclear Development Corp of America, the builder. Critical mass will be about 150 kg U-235 in a total of about 10,000 kg of uranium enriched to 1.5%. Fuel element rods will be arranged in 40 clumped subassemblies, each containing seven rods. Anticipated life of elements equals 5000 mwd per ton. This lifetime needs an initial excess reactivity of about 10 to 15%, gives a core life of 14 to 23 months at 80% plant factor.

Puerto Rico and AEC plan to build a 20,000-kw nuclear power plant. Unit will supply commercial power and serve as training facility for students of the University of Puerto Rico. Plans depend on Congressional approval.

Gas-cooled reactor experiment contract between AEC and Aerojet-General Corp is now being negotiated. Reactor will be erected at the National Reactor Testing Station in Idaho. This is the eighth type of reactor sponsored by AEC. It will be used for military package-power reactors, small civilian plants.

Radiation exposure increase from H-bomb testing, on a world-wide basis, is only a negligible fraction of our unavoidable exposure to cosmic rays, normal radioactivity in the soil, and the medical use of X-rays. Even if H-bomb testing were continued indefinitely at the present rate, no significant rise in background radiation level would be developed.

New utility group plans to build a nuclear-powered central station. The Carolina-Virginia Nuclear Power Associates, Inc, a non-profit corporation, plans to build this station in the area of the member companies: The Virginia Electric and Power Co., The Carolina Power and Light Co, The Duke Power Co, and The South Carolina Electric and Gas Co.

Radioisotopes take on a widening range of jobs. They now do such things as: locate malignant tumors; treat thyroid diseases and cancer; act as tracers in uptake of fertilizers by plants, soil fertility, plant diseases and fungicides. Industry uses them for thickness gaging, luminescence, activation of chemical reactions, sterilization of foodstuffs, radioisotope battery development, wear studies, leak location, pipe line tracing and oil well studies and treatment. In 1950 about 100 firms used isotopes; now there are over 1200 firms. Annual savings by 1966 may amount to a billion dollars, as we find more jobs for radioisotopes.

Asst Plant Engineer L Landau Asst Director W H Martin Plant Engineer F L Boberschmidt

SMILES ARE IN ORDER since electrical load growth presents no problem during planning of new additions

Power to grow ...electrically

NO. 4: INSTITUTIONS

PTG index of 3, planned

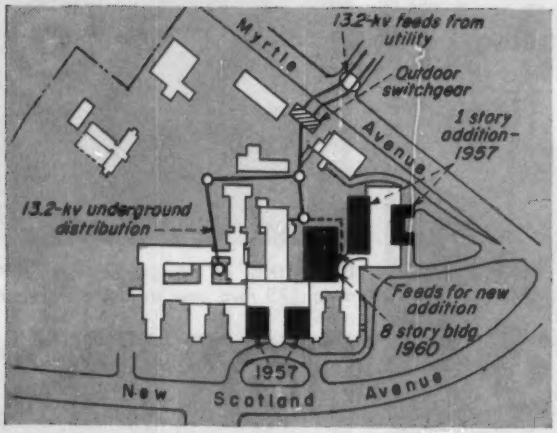
Load in this hospital tripled during 7-year span. But new loads are easily met with a 13.2-kv distribution system and ample primary switchgear. The 500-mva primary switchgear still has 175-mva reserve before matching available s-c currents

► ALTHOUGH the plant operating staff of the Albany Hospital have their share of tough engineering problems, primary electrical distribution is not one of them. They've been living with a top-drawer electrical supply and distribution setup for the past 7 years. It means hospital load growth can be met without major changes while offering trouble-free operation.

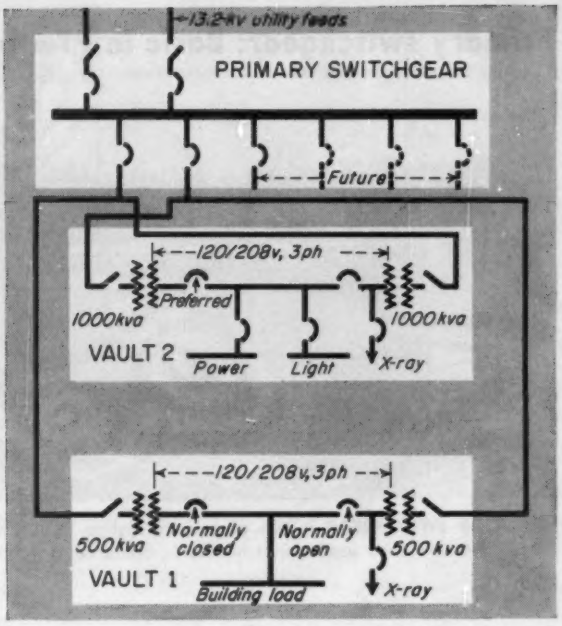
System redesign started here back in the late '40s. During World War II, hospital's administrative staff, consulting engineers and representatives of Niagara Mohawk Power Corp sat down and took a long-range look at the hospital's probable electrical power needs for the years to come: Basically, PTG planning (POWER, Oct 1956, p 92). At that time electrical power was being fed to the hospital from the utility's 4.1-kv system. Outcome of this conference was adoption of a 13.2-kv scheme to run from the utility's incoming feeders to transformer vaults tucked away within the hospital property line. A well-designed outdoor switchgear center is the receiving point for utility dual feeds. Distribution sketch, facing page, shows remainder of electrical primary arrangement.

Selecting 13.2 kv for the installation in 1949 was a forward-looking step well in tune with a general industrial trend. Today, power men and equipment makers are working with utility people toward the goal of "ideal" voltages while moving toward fewer voltage levels.

What is of interest in this electrical setup? Briefly, it's the PTG thinking that went into the planning of the system back in 1949—and it's paying off today. Keep in mind the Albany Hospital is an old institution. Back in 1830 when Albany's population was little more than 20,000, the beginning steps were taken toward the building of a great medical center for the upper eastern area of New York State. At that time Dr Alden March delivered a lecture before a group of Albany's prominent citizens on the urgency of establishing a medical college and hospital. But it wasn't until 1839 that the Albany Medical College was organized. It is interesting to find in the old minutes of the Board of Governors that early in 1855 the Hospital found itself striving for a way out of financial difficulties. Today, over 100 years later, this Hospital along with most others, is still seeking that elusive goal. In 1899 the Hospital boasted 100 beds. From that point, Albany Hospital has grown into a major medical center



PLANNED ADDITIONS will be met electrically by building a new vault and extending present underground duct system



AUTOMATIC TRANSFER shifts load to alternate feeder if preferred source fails. X-ray equipment is on separate feed

in '49, pays off at Albany Hospital

blanketing a radius of about 75 miles.

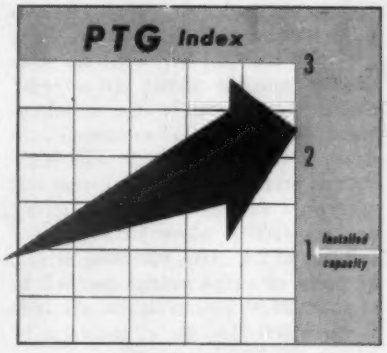
This growth has served as a stimulant in the design-thinking of hospital officers and engineers. On the electrical side alone, load growth in the past six years has topped 300%. Here's how the peak demands shape up:

Year	*Peak demand, kw*
1950	277
1951	289
1952	576
1953	684
1954	720
1955	810
1956	876

Primary switchgear lies at the heart of the in-plant PTG ability. Back in 1949, the Niagara Mohawk Power Co figured their available short-circuit energy as 325 mva at point of feeder entrance. Although this value has varied somewhat over the years, today it's about back to the original figure. All circuit breakers in this primary switchgear are rated 1200 amp, 500 mva. Each breaker is interchangeable. Cables feeding to the primary switchgear are single conductor 350-mcm, 23 kv, varnished-cambric and lead.

Voltage choice in the Albany Hospital, as elsewhere, hinged on several factors: load size, distance, equipment ratings and voltage levels available from the supplying utility. It's basic that bigger loads and longer distances point up the need for higher voltages. Plant engineers no longer consider 13.2 kv too dangerous to have around. Greater safety in today's equipment, both insulation and mechanical enclosure, make high voltage nothing to fear when kept in its place. All angles factored in, high-voltage level generally means lower cost, greater flexibility and expansibility. Selection of a high enough voltage is a key factor in planning power to grow.

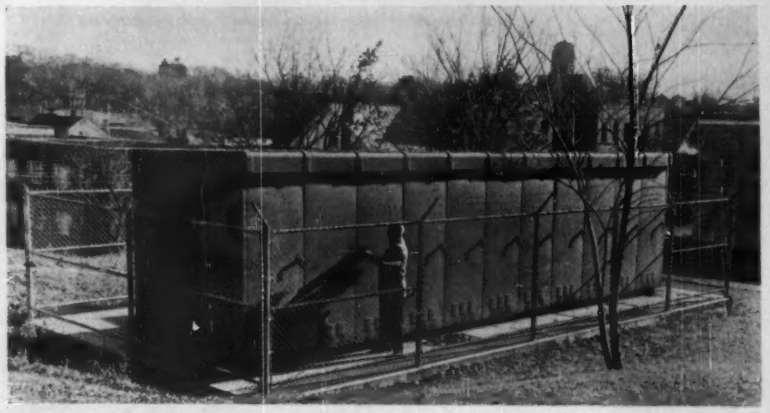
Each of the commonly used primary distribution voltages—2.4, 4.1, 13.2 kv—has its place. Yet many power men today still use the old rule of thumb: 4.1 kv for plants having a supply transformer and/or generating capacity of 10,000 kva or less . . . and 13.2 kv where there is a supply transformer and/or generating capacity of 20,000 kva or more. This, like any rule of thumb, must be seasoned with caution. And caution starts with an engineering analysis after checking available voltage levels with the supplying utility. In choosing any voltage, keep in mind your plant will probably grow (POWER, Sept 1956, p 75). That holds, whether



What's your PTG index?

By tagging the installed capacity as unity, the PTG index gives some measure of a system's expansibility. We define the power-to-grow area as the planned-for-capacity that can be economically provided and integrated into an existing system. And planned power-to-grow capacity divided by installed capacity is what we call the PTG index. It should serve as a practical guide for system planners.

Primary switchgear: Basic in PTG planning



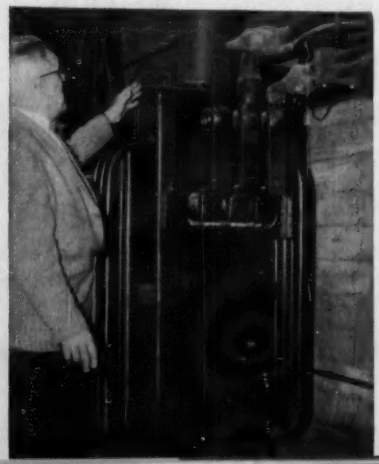
OUTDOOR SWITCHGEAR is hub of primary system. Cubicle space is provided for three times presently used circuit breakers. Spare ducts connect all cable manholes

IC RATING of primary breakers, 500 mva; 175 mva over available s-c figure

RELAY PROTECTORS in primary switchgear located opposite breaker locations

SECONDARY SUB, double-ended, includes two askarel-filled power transformers

UNDERGROUND VAULT houses oil-filled transformers; space for larger units



thinking of a hospital, commercial building or manufacturing plant. So, while 4.1 kv may cost less to install now, tomorrow's loads might well make 13.2 kv most economical over the long pull.

2.4 or 4.1 kv? The Albany Hospital was fortunate in that the Niagara Mohawk Power Corp was in a position to supply 13.2 kv. What if you're faced between 2.4 and 4.1 kv? When all factors are included—switchgear, motors, starters, growth potential—costs generally favor 4.1 kv. What are some of the tangible dollar advantages? Feeder costs generally dip as voltage rises. Many electrical estimators still figure a modern armored cable high-voltage primary feeder installation will rack up a saving of $1.00 per circuit kva per 1000 ft where 4.1 kv is used in place of 2.4. Also, operating at 13.2 kv poses an added savings over 4.1 kv of about $0.50 per circuit kva per 1000 ft where individual circuit loads can be kept in the 3000-kva range.

Switchgear costs are an important item too. At 4.1 kv, switchgear for a given interrupting capacity often costs less than comparable gear at 2.4 kv. Also, in a 4.1-kv system if a 1200-amp breaker is needed, a more expensive 2000-amp breaker would be used at the lower voltage.

High-primary voltage is no cure-all. Far from it. In an old institution such as the Albany Hospital, the secondary portion of the electrical installation is generally the toughest nut to crack. Here, in-wall conduits and panelboards present a major problem in fitting in added capacity (POWER, Nov 1956, p 75). One thing is sure: if this hospital were starting from scratch tomorrow, the 460/265-v scheme would get major consideration.

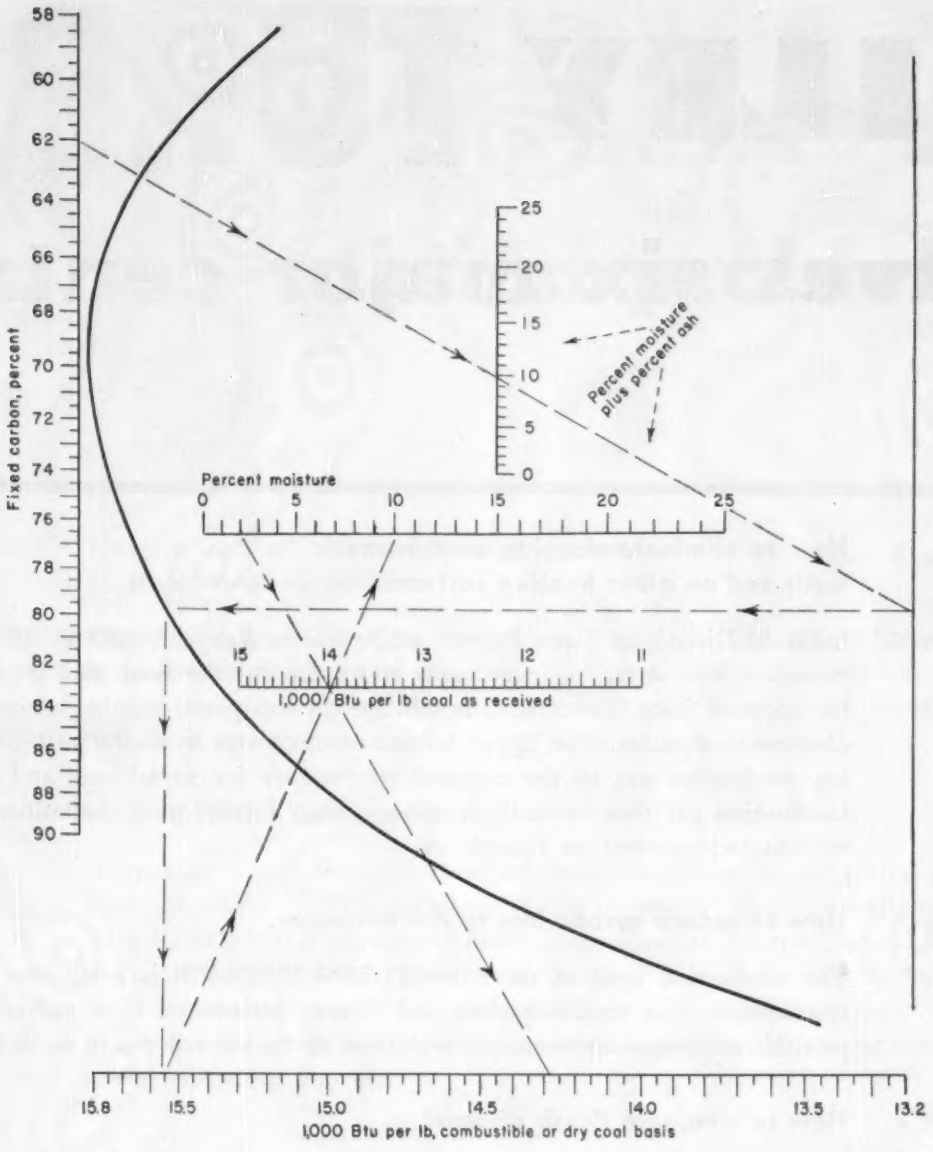
Service continuity was taken care of with a dual-feeder arrangement. Note that both incoming feeders tie to the same primary bus. Should either feed drop out, other can carry the load. And if either of two feeder breakers on the load side should trip, automatic throw-over switches shunt load onto remaining live feeder. This is but one of the features worked into the feeder system scheme by Schmidt, Garden & Erikson, architects and engineers.

PTG thinking at the Albany Hospital goes beyond the voltage question and selection of primary switchgear. In touring the installation there is ample evidence of look-ahead planning. *Example:* Underground Vault No. 1 was so proportioned that replacement of the present 500-kva transformers with bigger units will be a cinch when load growth warrants it. Ducts from primary switchgear to manholes and vaults have built-in spares for growth needs.

How is the '49 PTG plan paying off today? In discussing this point with Assistant Director W H Martin and Plant Engineer F L Boberschmidt, two generalizations were made. First; with the higher primary voltage and ample cubicle capacity, new loads are easily added. Second; feeders, bus and breakers were so sized that meeting load growth is no problem, either from actual load in amperes or interrupting capacity of breakers. When new buildings are to be fed, sketch, p 111, it will simply mean installing additional vaults, supplying them directly from existing primary distribution scheme.

Power's DATA SHEET

No 294



Heating value of bituminous coal

► THIS CHART will help you estimate the heating value of bituminous and semibituminous coals when you know the fixed carbon, ash and moisture contents.

Example: Find the heating value of a bituminous coal on the combustible, as received, and dry bases when it contains 62.0% fixed carbon, 8.0% ash and 2.0% moisture.

Connect 62.0 on vertical fixed-carbon scale with 10 (sum of moisture and ash) on center vertical scale with a straight edge and project to intersect blank index line at right. From here project horizontal line to intersect curved line at left, then drop vertically to read 15,560 Btu per lb of *combustible.* Connect this point with 10 on upper horizontal scale and read 14,000 Btu per lb coal *as received* on middle horizontal scale. Next, connect 14,000 Btu with 2.0 (moisture) on upper horizontal scale and read 14,280 Btu per lb of *dry coal* on lower scale.

D S DAVIS *Virginia Polytechnic Institute*

© POWER

RILEY TURBO

solves six major central

Problem 1: **How to eliminate slagging on furnace walls and on other heating surfaces.**

Solution: Intertube Directional Flame Burners used with the Riley TURBO FURNACE are placed on one elevation, immediately above the furnace floor and are arranged for opposed firing. Combustion is substantially completed at the bottom of the combustion chamber. The upper furnace envelope area serves the purpose of cooling combustion gas to the required temperature for superheater and reheater. Combustion gas rises vertically in the secondary furnace without stratification and without impingement on furnace walls.

Problem 2: **How to reduce carbon loss to the minimum.**

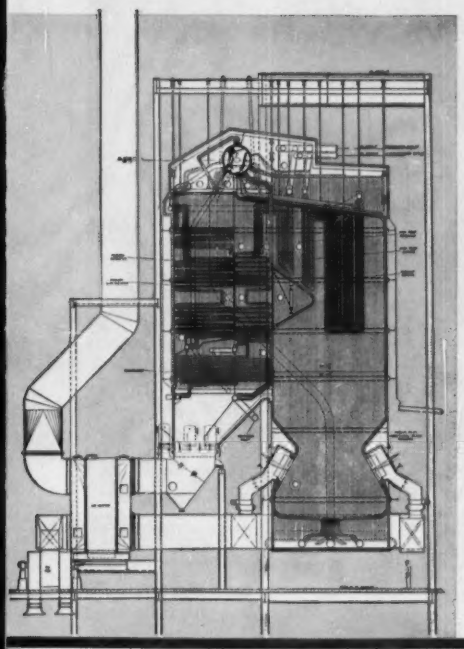
Solution: The combustion zone of the Riley TURBO FURNACE is a chamber of high temperature, long residence time, and extreme turbulence. Here pulverized coal particles are completely consumed with most of the ash reduced to molten slag.

Problem 3: **How to eliminate flyash disposal.**

Solution: The almost negligible trace of flyash carried in the flue gas of the Riley TURBO FURNACE is collected in rear pass hoppers and dust collectors and reinjected thru the burners for reburning of combustibles and final disposal as molten slag. Molten slag is quenched and removed as in any conventional slag tap furnace.

Problem 4: **How to change from gas and oil to solid fuels firing at less cost.**

Solution: Conventional type steam generating units designed to burn gas or oil must be taken out of service for extensive and costly alterations when converting to solid fuels firing. Because furnace exit gas temperatures are substantially the same for all fuels fired in the Riley TURBO FURNACE, immediate conversion to solid fuels without change to furnace and heating surfaces is possible.



FURNACE
station problems

Problem 5: **How to obtain uniform heat distribution to steam heating surfaces.**

Solution: The vertical direction of combustion gas leaving the TURBO FURNACE burning zone uniformly within the area of the vertical furnace walls insures equal furnace exit gas temperature from side to side and front to rear. Uniform heat absorbtion by superheater and reheater elements is thus assured.

Problem 6: **How to reduce operating costs.**

Solution: Burners on large conventional central station boilers are usually placed at several levels requiring complicated facilities for operation and supervision. Riley's TURBO FURNACE Directional Flame Burners are all located near the bottom of the furnace on one level. Plants can be designed so that the turbine, burner platform and control room are all on one floor level. Complete automatic electronic burner controls with fool-proof safeguards against flame failure are available for remote operating control.

Riley TURBO FURNACE boilers have been sold for capacities over one and one half million pounds of steam per hour. The operating characteristics of Riley TURBO FURNACES assure effficient performance when burning coal, oil, fluid coke, delayed coke, gas and lignite individually or in combination.

A survey of your plant by a consulting engineer could show ways of making surprising savings in your power costs.

RILEY
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WORCESTER, MASSACHUSETTS

Sales Offices: Worcester, New York, Philadelphia, Buffalo, Pittsburgh, Cleveland, Detroit, Chicago, Cincinnati, Charlotte, New Orleans, Atlanta, St. Louis, Kansas City, St. Paul, Houston, Denver (Englewood), Salt Lake City, Los Angeles, San Francisco, Portland, Seattle.

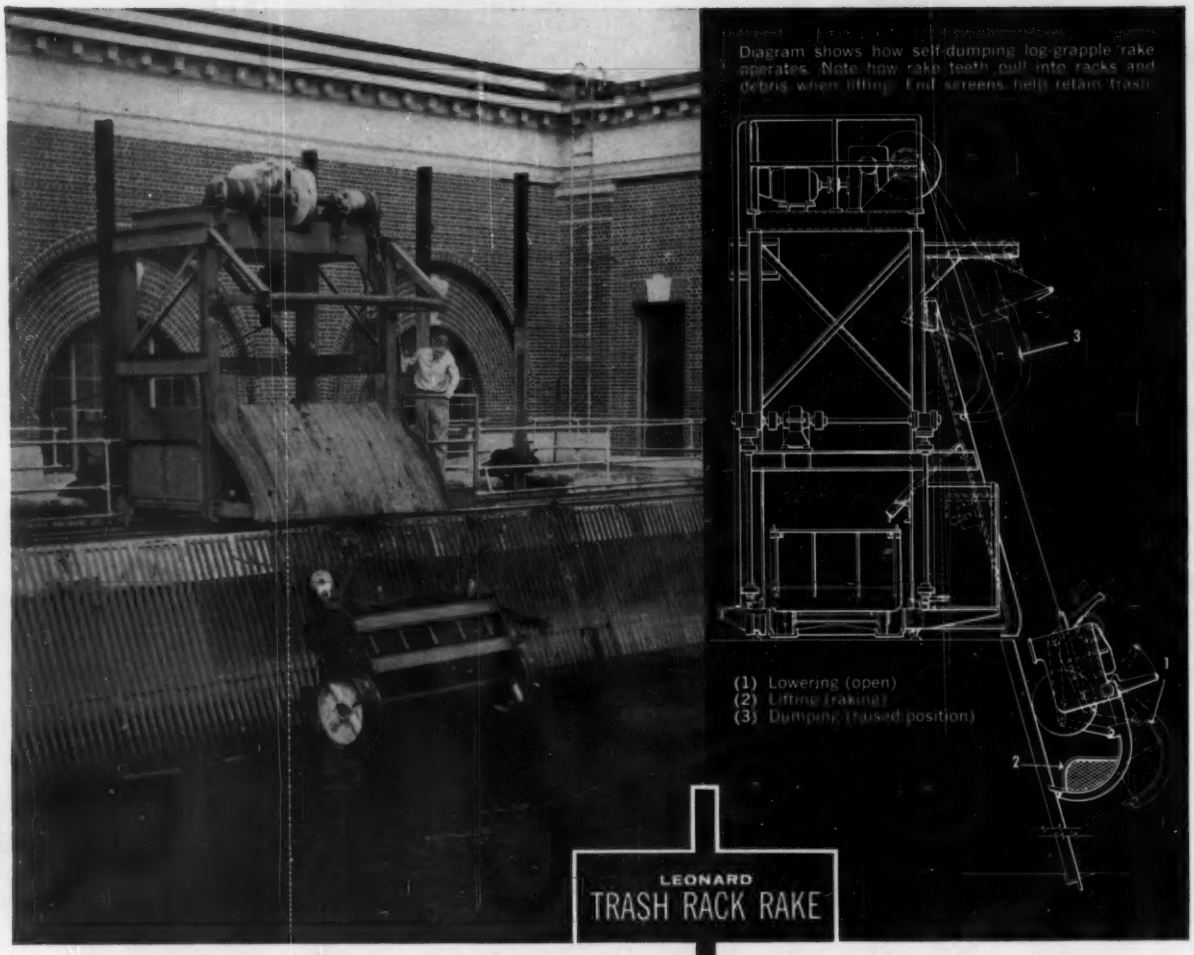


Diagram shows how self-dumping log-grapple rake operates. Note how rake teeth pull into racks and debris when lifting. End screens help retain trash.
(1) Lowering (open)
(2) Lifting (raising)
(3) Dumping (raised position)
1
2
3
LEONARD
TRASH RACK RAKE

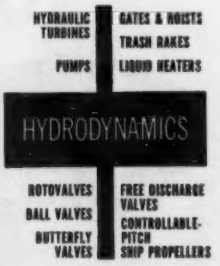
New 8-foot, self-dumping SMS rake at Niagara Mohawk Power Corporation's Black River Station is one of five recently installed by this company.

Two New Self-Dumping SMS Trash Rake Designs CUT CLEANING TIME AND LABOR

Now SMS offers you two improved Leonard trash rack rakes, both regular and log-grapple types. These self-dumping rake designs make operation easier and quicker, permit you to clean a greater area faster. Both new rake types are now available as additions to the SMS line of standard rake designs.

SMS Leonard rakes operate directly on trash rack bars . . . ride down over stubborn obstructions and work them loose. Such freedom of movement assures fast, easy cleaning. Initial costs are low because the width of SMS rakes can be kept to the minimum required for handling for trash and the expense of guides attached to racks, or embedded in piers is eliminated. These rakes are of simple and rugged construction, designed for outdoor service and require minimum maintenance.

To get full information on Leonard trash rakes, or on other SMS accessories and hydraulic turbines, write to S. Morgan Smith Co., York, Penna. For Leonard rakes, request Bulletin 158.



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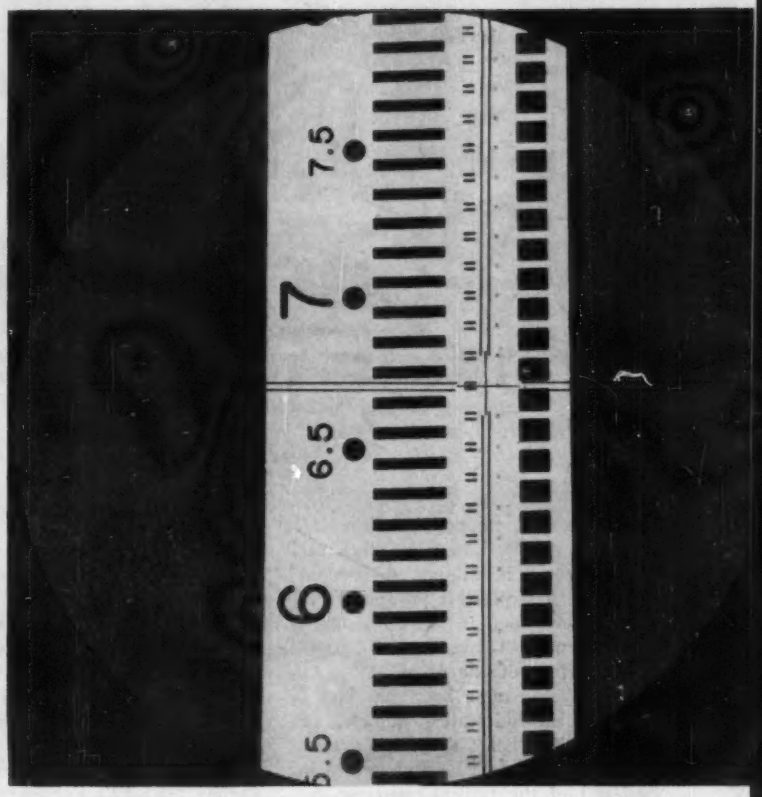
STEVE ELONKA
Associate Editor in Charge



Now, you can see your bearings move with this . . .

Telescope-mirror alignment method

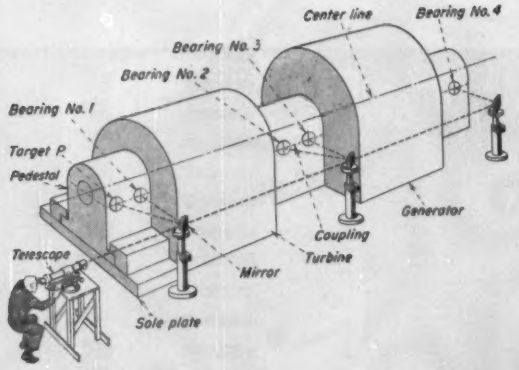
At long last, you can tell misalignment within thousandths of an inch in machines that are running and under full load. Compare this "hot" data with misalignment when machine is cold, then, for best results, realign bearings to favor hot machine

By **HERMAN SCHULTZ**
Consolidated Edison Co, New York City

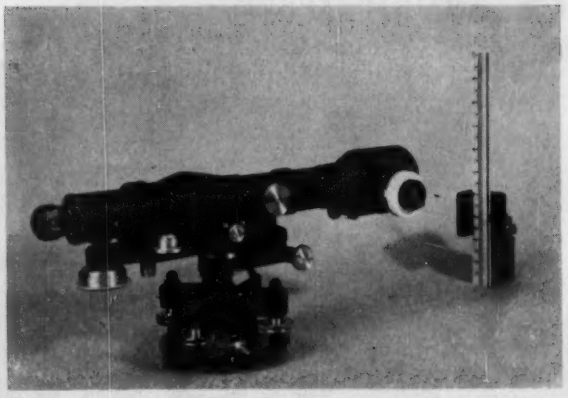
► KNOWING EXACTLY how far bearings are thrown out of line on a hot machine has been a lively plant topic for years. But there was no practical way to get accurate answers. Now we've licked this ancient problem with an alignment telescope and mirrors.

Cold alignment. A few years ago we first used a telescope instead of the tight-wire method to align our large turbine-generator units during major overhauls, photo, p 119. (*Ed. note:* See, "Now you can shoot your bearings in line," POWER, May 1954.) Here the telescope is aimed at targets centered in each bearing. But, as is the case with the old tight-wire method, the rotor must be removed. This can only be done while machine is open.

Once bearings were so aligned, question was how much they'd be out of line after machine was started and put under full load. We knew that some bearings get dangerously out of line



HOT-ALIGNMENT SETUP is to aim telescope parallel to center line of bearings while mirrors reflect bearing targets



TELESCOPE has tilt of one second of arc (about 0.0015-in. at 25 ft), shows the exact position of bearings in the machine

during normal running conditions. If we knew exactly how much, then each bearing could be aligned so it would be in the best possible position during normal operation.

Hot alignment. Sketch, above, shows how bearings of one of our large turbine-generator units were checked by this new method while completely assembled and hot. Targets, or check points, were installed on every bearing pedestal of the turbine-generator during a recent overhaul. These targets were placed on the side of the pedestals to transfer the inside alignment position to the outside. We then mounted a second target on the forward end of No. 1 pedestal, sketch, which we shall call target *P*. This target was used to measure pedestal tilt between the relatively cool end at target *P* and the hotter end at second target on the same bearing.

Next, we mounted our telescope a few feet in front of No. 1 bearing pedestal and 15 feet to the right of the turbine's center line. This gave us an unobstructed line of sight parallel to both the turbine and generator. Stanchions were fastened to the floor alongside the bearing targets and in the telescope's line of sight.

Each stanchion was equipped with a cup mount to receive a mirror. In this way, all targets could be observed by the telescope without disturbing the telescope once it was set. All we had to do was move the mirror from stanchion to stanchion as we looked 'around' the two machines at every target from one spot.

Our optical mirror is ground to a quarter of a wave length and fitted with a 10-sec levelling device. This assures an accuracy of 1.2 mils in 10-ft distance. Telescope has an accuracy of 6 mils at 120-ft distance.

First test. All targets were set to zero on Jan 22, 1955. We observed them while machine was cold on Jan 22, 23 and 24. No alignment changes took place until the turbine was heated through the exhaust line. That was on Jan 24 at 9:00 am. See elevation chart on page 119.

Turbine was started at 4:00 pm against 285-psi backpressure. We slowly brought turbine up to full speed of 3600 rpm at 9:00 pm. At that time we made some valve adjustments and tested the overspeed trip. Generator was phased in at 10:15 pm and load slowly increased to 60 mw. Load was reduced to 52 mw on Jan 25 at 12:30 pm and turbine backpressure was increased to 420 psi. These moves caused the bearing elevation changes that you can easily trace on the elevation chart, p 119.

Highest bearing elevations were reached on Feb 4, giving a definitive misalignment, as chart shows. From that point, bearing elevations started going down. We reasoned that ambient temperature was the cause. Reason for our thinking was that all elevation readings were based on No. 4 bearing. So when ambient temperature raised No. 4, that gave impression that the bearing elevations went down. Because we worked from No. 4 bearing, which was our fixed position, we had no way to know its actual rise.

Tilting. No. 1 bearing pedestal tilted between the two targets placed on it from time turbine started. It reached a maximum tilt of 103 mils on Jan 29. From then on it gradually declined to 65 mils. This tilt is represented on the elevation chart by the distance between No. 1 bearing line and heavy *P* line.

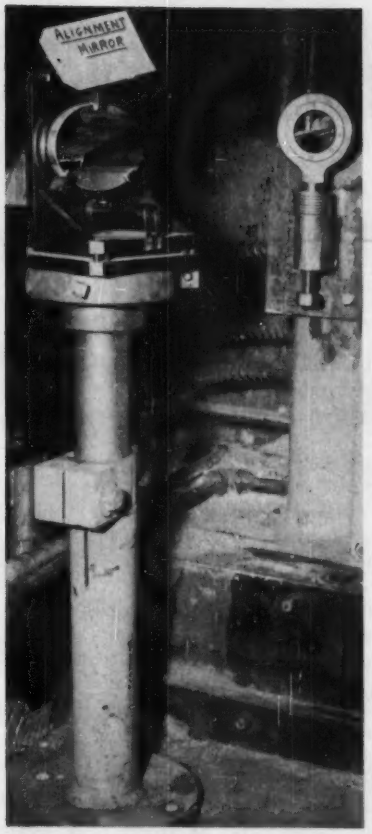
We had anticipated that No. 1 pedestal would tilt. That's why we left the sole plate level during the overhaul and installed micrometer check points on this plate in order to measure tilt. But we couldn't detect more than a few thousandths from these points.

Sole plate was checked with a sensitive level at that time. Results were same as with the telescope. Then we inspected the eccentricity coil mounted in No. 1 bearing pedestal. Wear was 85 mils.

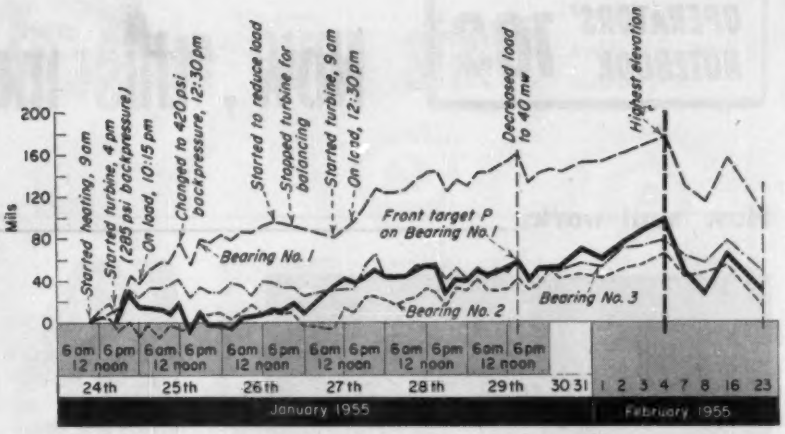
Next, we plotted bearing elevation changes from data obtained by telescope. As chart shows, a definite trend was established. No. 1 bearing reached its highest elevation on Feb 4 with 175 mils over No. 4 bearing. After that it dropped back to 102 mils on Feb. 23.

Another interesting point was the tilt of No. 1 pedestal. On Feb 26 we measured a tilt of 85 mils. Unit was then shut down for balancing. During the 12-hr shutdown period, pedestal tilt decreased to 45 mils. This was caused by decrease in elevation of No. 1 bearing during this time. Fifteen hours after unit was started we measured a tilt of 80 mils. During April 28 shutdown, same tilt was noticed. At that time a 70-mil tilt forward reversed itself to a 10-mil backward tilt during a 48-hr period.

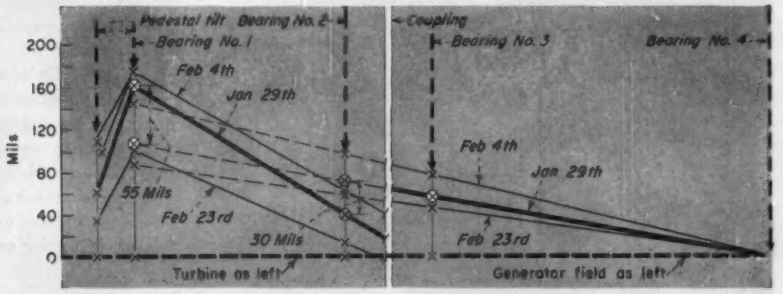
Backward tilt. Cause of this reversal was interpreted as being from expansion on the turbine side of foundation under No. 1 pedestal. Expansion itself was caused by steam piping and temperature changes. A second contributing factor was difference in foundation expansion between top and base. Here a 120-mil expansion was measured on the turbine floor level in front of No. 1 pedestal, which is considerable.



OPTICAL MIRROR on stanchion, target mounted on machine's bearing pedestal



MOVEMENT of each bearing is clearly charted through every stage of warmup period, then during several weeks under full load. Max movement reached 160 mils

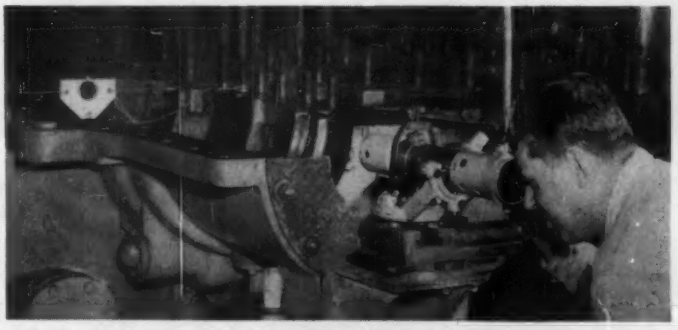


COLD, HOT ALIGNMENT elevation shows pedestal tilt of over 0.060-in. caused by steam lines beneath pedestal. Lines were later insulated to correct the condition

We made several balance moves during Feb, Mar and April to correct excessive shaft vibrations. But the turbine spindle didn't respond to these balancing moves. So we decided cause was something else.

On April 28 we set up the telescope again to make another hot alignment check. We learned that No. 1 bearing was 15 mils high, while No. 2 bearing was 20 mils high. Unit was removed from service for a coupling check on April 29. Coupling check showed the same results as our telescope. So we lowered No. 1 bearing 20 mils and No. 2 bearing 24 mils to correct the misalignment. From experience with this unit, we know that our telescope is thoroughly reliable. We *can* accurately check alignment of our hot machinery while running and under full load.

Telescope used for hot alignment mentioned in this article is a Keuffel & Esser, known as a tilting dumpy level. It has four-screw leveling, an erecting telescope, coincidence reading bubble, telescope axle at mechanical center, and large precise tilting wheel.



Aligning bearings of cold machine...

with a telescope is now doing away with the ancient tight-wire method. Here, a micrometer target is centered in bearing bore. Telescope is set on zero, instrument adjusted horizontally and vertically so that target cross wires and telescope reticle cross hairs are in same line of sight. This line of sight becomes a reference line for the machine's entire length. Micrometers are used to center targets in all other bores of turbine and generator stator. Center-line displacement of these other bores is then measured from reference line on micrometers and recorded. From these readings, you can plot curve on cross-section paper showing "as found" alignment of bearings. Once machines are aligned 'cold,' close them up and take 'hot' readings with mirror method as explained.

OPERATORS' NOTEBOOK 103

Now, this mechanical seal

How seal works

FROM PACKAGE, seal goes to stuffing box in one piece

► To LICK PROBLEM of installing expensive mechanical seals into a machine piece by piece, this seal comes fully assembled. All you need do is slide it over shaft, tighten a few screws, as shown, and you're in business.

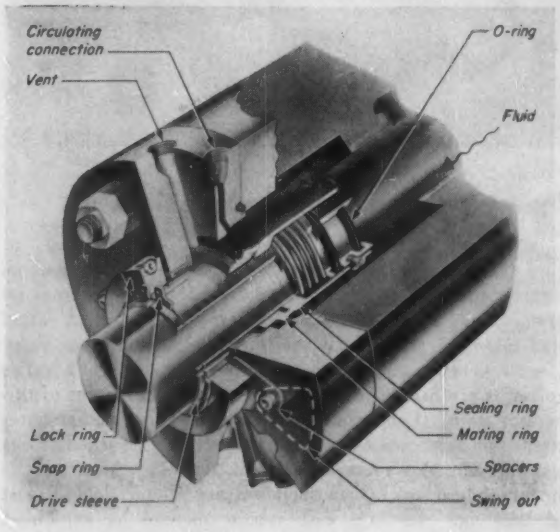
Known as the unitary design, it's for pressures to 1000 psi, temperatures to 250 F and shaft speeds to 4000 fpm. It also seals corrosive liquids. Unitary design solves problem of expensive seal faces (finished to within a few light bands), being damaged by inexperienced help when installing mechanical seal into a machine.

To install, slip assembly over shaft, bolt gland in place against gasket, lock seal onto shaft, disengage the two spacers and start the pump. Of course you'll have to hook up circulating connections of design shown. CAUTION: Be careful not to damage O-ring on burrs when sliding seal over shaft. Damaged O-rings are a common cause of seal failure.

Two spacers are used. So you don't have to measure distance between lock ring and gland to properly position seal on shaft. Slide assembly into position and draw up on gland nuts with lock ring resting against spacers. Take up on cap screw to secure drive sleeve to shaft. Then swing spacers away from shaft. Even if you don't, spacers are soft brass and will wear, depending on shaft thrust movement. Split shaft-sleeve locks the seal to shaft from outside. Auxiliary stuffing box diverts any leakage to vent or drain. For more information on mechanical seals, see POWER, Mar 1956, pp 109-132.

—Courtesy, Garlock Packing Company, Palmyra, New York.

What you should know



HANDY TIPS. Even though this seal comes completely assembled, handle it carefully; keep it away from dirt while installing. Since the O-ring that seals the shaft against fluid is so critical, make sure shaft is perfectly smooth before you slide the seal over it. Remove sharp corners at end of shaft since a tiny cut in O-ring will give trouble.

Make sure you give manufacturer correct measurements for new seals. Before installing, it's a good idea to check pump's shaft for runout. Do this with a dial indicator. It stands to reason that if the shaft is bent, or if runout is more than the seal can handle, you'll have trouble.

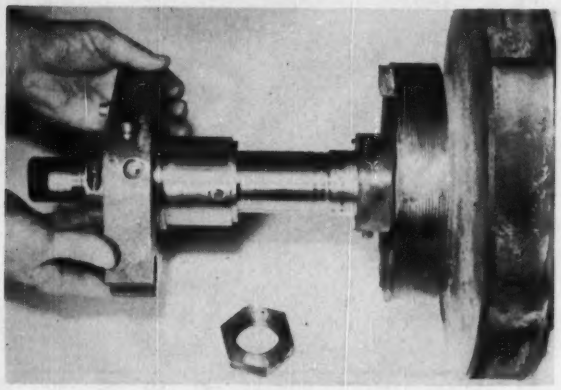
If used for hot liquids, prevent vapor binding at seal faces. Remember that these faces must be flooded at all times. You can prevent vapor binding in various ways, depending on your circulating hookup to seal.

Before starting machine with new seals, test with static pressure to make sure seal doesn't leak. It's good practice to rotate shutdown mechanical-seal-equipped machinery once a day. This helps keep the sealing faces in good shape and lubricated. One more thought: Make it a habit to keep fluid pressure inside a pump while it is shut down.

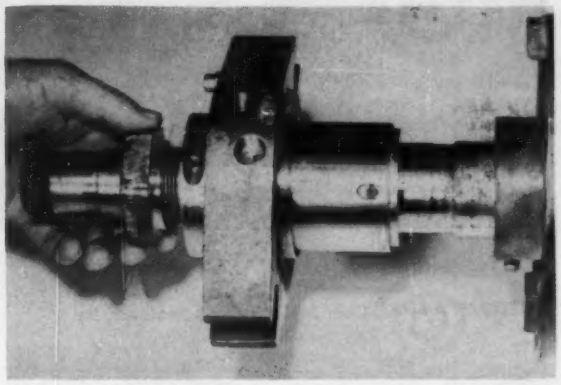
comes ready to slide over shaft

By STEVE ELONKA,
Associate Editor

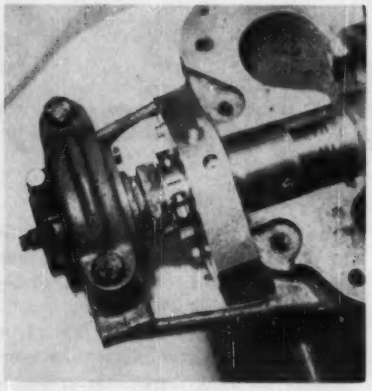
How to install



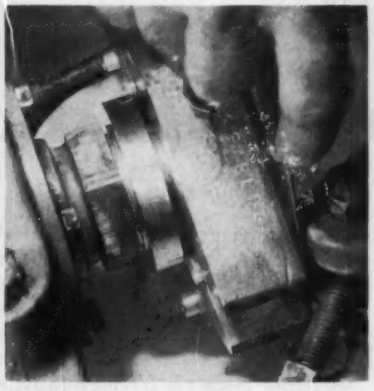
1 Clean and smooth shaft and shaft sleeve to remove burrs. Slide mechanical seal over shaft carefully as shown here



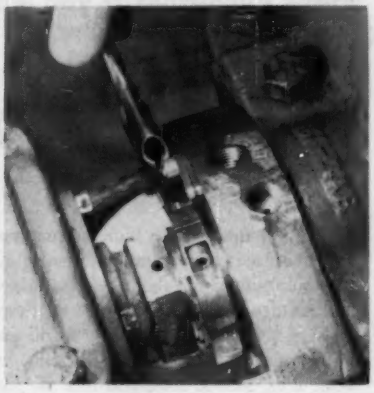
2 Install shaft-sleeve nut if your machine has one. Nut holds sleeve on the shaft, has nothing to do with this seal



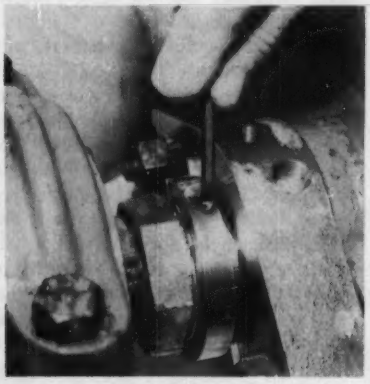
3 With seal on both ends of impeller shaft, lower unit into pump casing



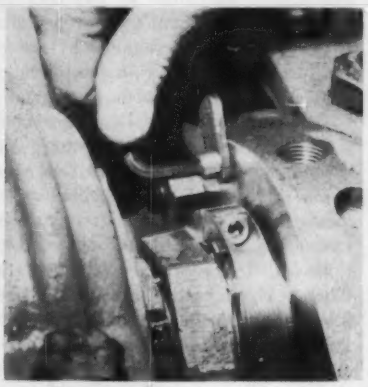
4 Apply gasket to casing surface. Install, trim flush with face of box



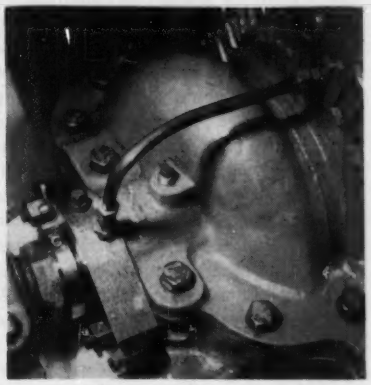
5 With gasket between the gland and casing, tighten gland bolts evenly



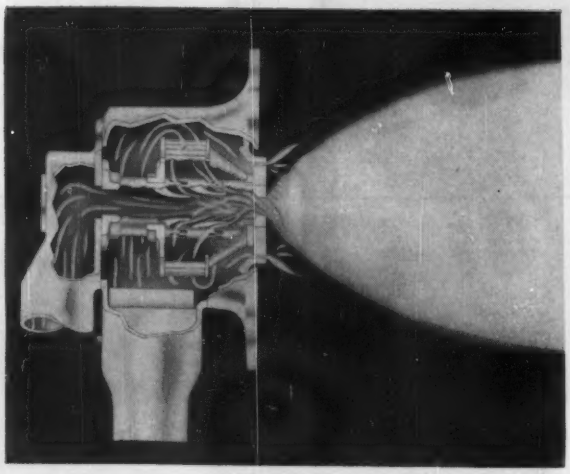
6 Tighten lock collar to produce drive for rotating parts of mechanical seal

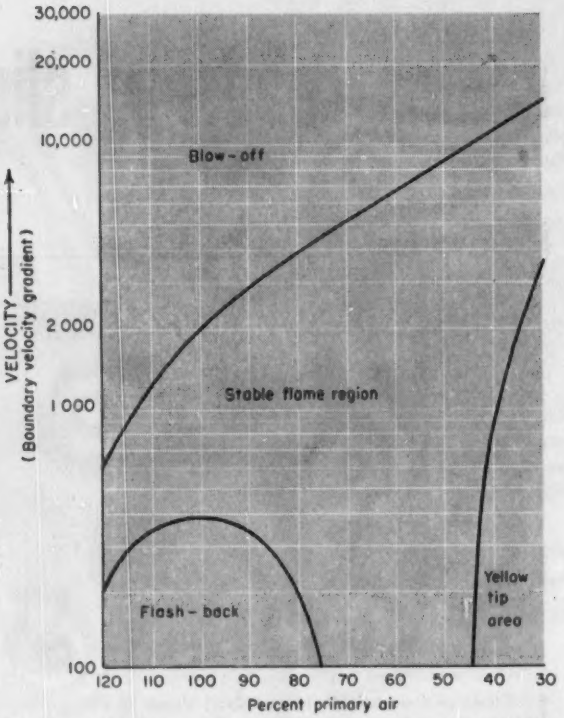


7 Swing soft brass spacer ears out of engagement now that seal is in place



8 Pipe gland connection to pump discharge. Plug other hole if not used





1 Bureau of Mines curve shows general conditions needed for stable flame when using gas of high methane content

By EDGAR A BURT, Chief Engineer, Orr & Sembower, Inc.

You need a stable flame plus stable stack conditions if you want to . . .

Get good combustion efficiency

► IN GENERAL, we use four major types of gases for firing boilers: manufactured, liquified petroleum (LP), mixed and natural. All can be broken down more specifically, but since natural gas is the most widely used, we'll point out what it is, how it acts, and how we can tell when we're getting top-notch results when firing it.

Natural gas, so named because it's taken from the ground, is either burned "as is" or it may first be processed chemically. It's about 95% by volume methane and ethane, the two lightest gases in the paraffin series. Usually, methane is 7 to 9 times greater by volume in the composition of natural gas.

Like any other fuel, gas needs air to burn so we use excess air to make sure we have enough for the complete chemical reaction of combustion. Most burners are designed to provide excess air, but the best use a minimum—about 15 to 25% more than is chemically required.

Stack gas analysis tells us whether or not we're getting complete combustion. Usual method is with an Orsat which shows presence or absence of CO and percentage of CO_2. These readings permit us to pinpoint the amount of excess air we need for good combustion reaction.

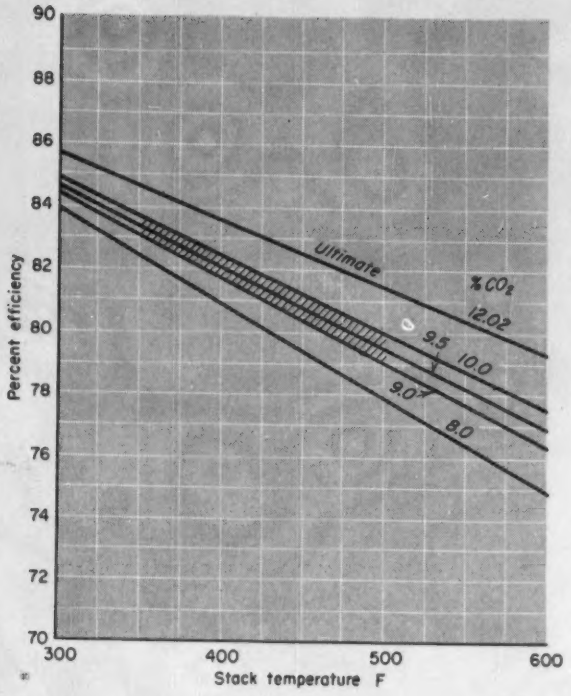
Air and gas mixture must be thorough, or smooth and even combustion can't take place. If it's only partially mixed, we can have an even reaction but it won't be complete. This is because heat is required for a complete combustion reaction. If gas and air mix slowly in a confined furnace that is being cooled (surrounded by water) the furnace walls may absorb too much heat for the reaction to continue.

Good mixing generally means splitting the air supply into primary and secondary. Primary mixes with the gas *before* ignition occurs and then, as the mixture's burning, secondary air is introduced. It's possible to have combustion with no secondary air, but the flame is short, hard, fluttery and makes loud ignition, extinction noises. A short flame gives more heat transfer in the combustion tube and lower rear tube sheet temperatures, but smooth combustion is hard to get and the difficulty more than counterbalances the flame pattern gain. Too, if you're firing oil with the same burner you must have secondary air to prevent carbon formation and smoke.

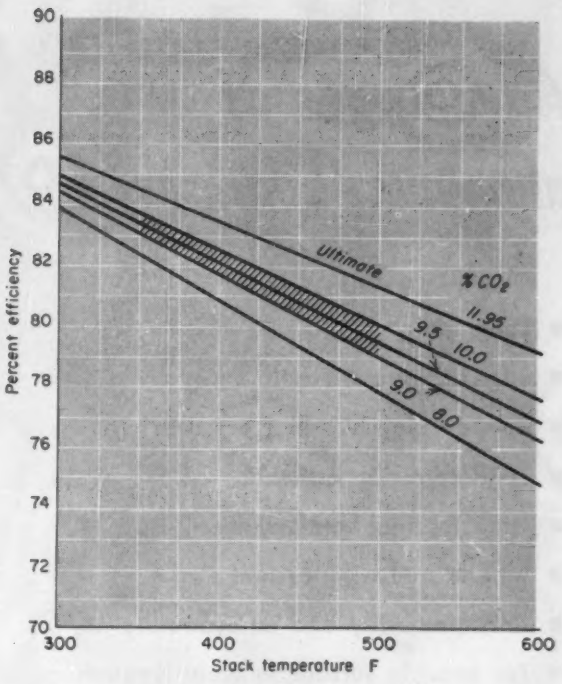
Let's look at how primary air affects flame pattern and stability. The more primary air used, the shorter and more compact the flame. Decreased primary air lengthens the flame and makes it 'lazy.' In a confined furnace this flame often produces CO which, of course, we want to avoid.

Flame appearance changes with change in primary air. At 100% (all air chemically needed for primary combustion) the flame is clear blue. As primary air decreases from 100% the flame takes on a hazy blue. With further decrease the flame begins to 'yellow-tip.' Here we get what we called a 'lazy' flame because the yellow tip seems to hang on the end of the flame.

Flame stability (which means that the flame will stay in one position with relation to the burner face) is perhaps affected most by primary air. Without stability, we can't have a smooth and even fire. It'll either flash back or blow off. Aside from the inefficiency in-



2 Typical combustion efficiency chart for an Oklahoma gas, 1064 Btu. Shaded range indicates good performance



3 With an Ohio gas, 1040 Btu, results are similar. Drop in CO_2, stack temperature rise means loss in efficiency

from your gas-fired boiler

volved, an unstable flame is noisy and obviously dangerous.

To have a stable flame the primary air-gas mixture velocity through the port must be about equal to the flame reacton speed (linear speed at which the flame will burn). If flame speed is greater than mixture speed through the port, the flame will burn back inside of the port and we have what is known as flashback. It'll only burn back as far as there's air to support combustion. But if flame speed is considerably greater than mixture speed, we get a fast flashback and the flame goes out.

Flashback isn't too much of a problem in natural-gas firing because it's a slow-burning gas and flame speed doesn't often exceed mixture speed. Big danger lies in using other gases of high hydrogen or carbon-monoxide content with a burner designed for natural gas. Their flame speed is much higher than methane and flashback can be severe.

Blowoff is the other major cause of an unstable flame. Here, the situation is reversed—primary air-gas mixture speed exceeds flame speed—and the flame lifts and moves away from the burner face. If the condition isn't too aggravated the flame will lift, then come back to the burner face with a vibrating motion and very audible pulsation. We can get this in natural-gas firing because of the low flame speed.

Bureau of Mines curve, Fig. 1, for methane isn't mathematically accurate for use with all burners, but it gives a general explanation of what happens when you fire these gases.

Horizontal axis is percent of primary air required chemically for combustion (100% theoretical air). This isn't actual percentage of total air used, but is based on what must be used for complete combustion.

Vertical axis is boundary velocity gradient (slope of the velocity curve) at the edge of the port. This slope is proportional to the velocity of the primary air so we'll discuss it on that basis. Keep in mind that (1) the entire diagram indicates what happens in general (2) we're not talking about any concrete and actual velocities.

Note the small flashback area. It's not only small, but it ends at about 75% primary air. With this much primary air we'd have loud ignition and extinction noises so we use less than the 75% maximum. Too, if we were using oil with the same burner we'd cut back on primary and feed more secondary air to prevent smoke and carbon deposit in the form of soot.

Below 45% primary, we note the flame has a tendency to yellow-tip. We avoid this because, aside from forming CO, it makes the flame too long. In a horizontal tubular boiler this can mean high rear-tube sheet temperatures and could cause tube end leakage problems or refractory difficulties.

We know, then, that the amount of primary air should be between yellow-tip limit and flashback area. In this range it should be near the maximum to make the flame as short as possible.

With primary air established between these limits, velocity of the air-gas mixture should be held below the blowoff line on the curve. This will depend upon port size. So it follows that if the port is sized to limit velocity, we'll get (*Continued on page* 194)

Advantages of aluminum bearings

- Long life
- High fatigue strength
- Support high bearing pressures
- High corrosion resistance
- High thermal conductivity
- Simple and easy to make
- Conformability and embedability
- No bearing surface to wear through

By R F SCHAEFER and D B WOOD
Aluminum Company of America

Aluminum main bearing for diesel...

► POINT COMFORT, TEXAS WORKS of Aluminum Company of America has 220 gas-burning radial engines, generating 275,250 kw of electricity. With a total of 400,000 hp, this is the world's largest internal-combustion engine plant.

Gas-burning radial engines were introduced in 1950, following development work by both Nordberg and Alcoa engineers. The engines are 2-cycle, 14-in. bore and 16-in. stroke—first 120 engines are 11 cylinder, last 100 are 12 cylinder. They develop up to 2125 hp, 1500 kw at 400 rpm. Units are designed with port scavenging and port exhaust. Advantages are simplicity, low maintenance and the fact that they pack a great deal of power into a small area.

Aluminum bearings. Late in 1949 a complete set of aluminum bearings were installed in Engine C-1, one of the last built on the original order at Point Comfort plant.

Engine C-1 is about 2000 hp, has 11 cylinders, with a 12-ft top diameter. Bearings of aluminum alloys *A* and *B* (characteristics explained later) were installed as follows: Alloy *A*: one lower main bearing, one upper main bearing, one master-bearing bushing and one generator-shaft bushing. Alloy *B*: two pinion-shaft bushings, 11 knuckle-pin bushings and 11 piston-pin bushings.

This engine was placed on the line on April 28, 1950. On Sept 8, after 2059 hours of operation, the bearings were inspected. Aluminum bearings showed no wear.

On Feb 22, 1951, after 10 months of hard service, bearings were again inspected and again showed no wear. But in 1951 upper main bearings in the other 119 engines began to fail. These engines contained bearings of bronze-backed babbitt.

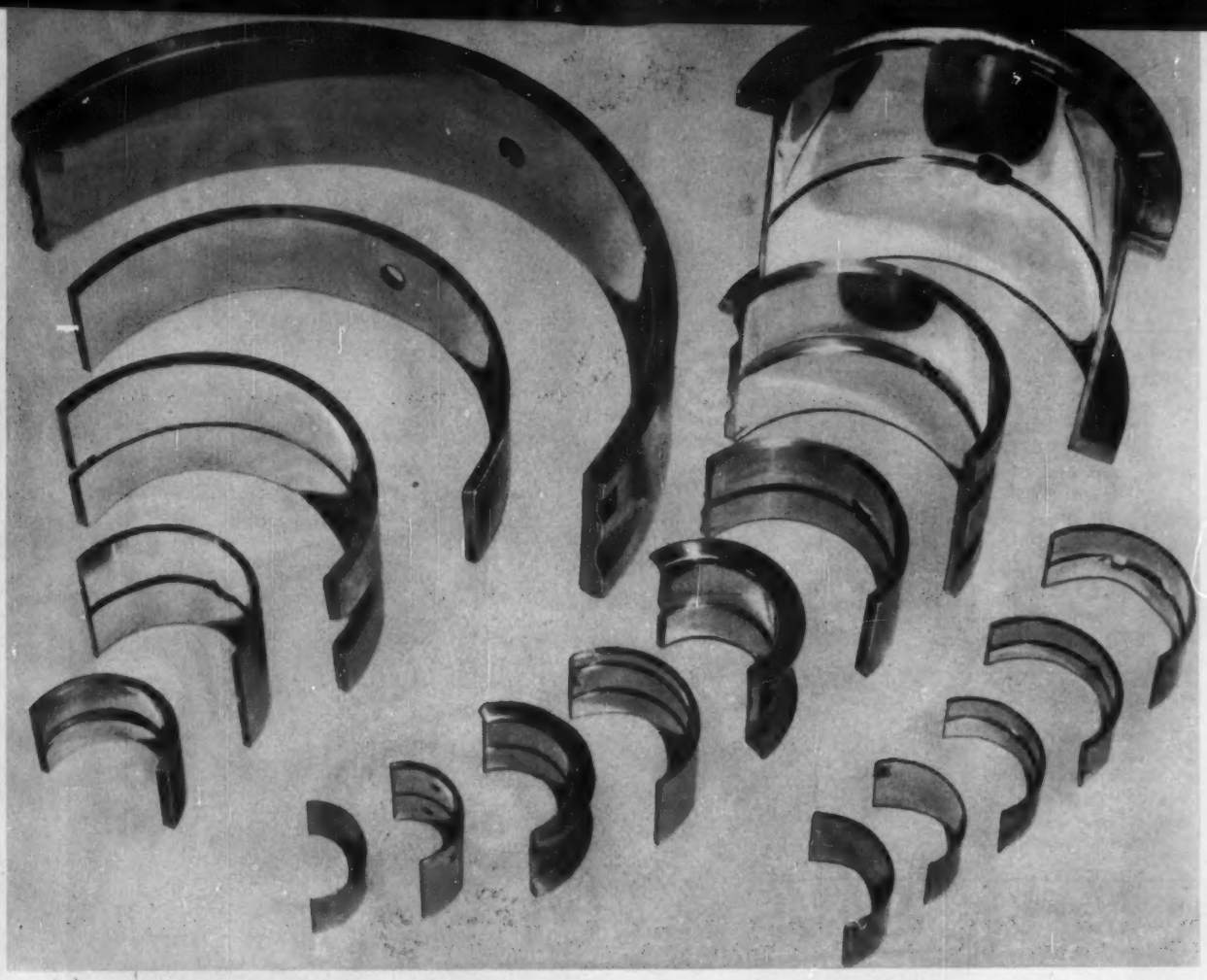
The following bearings in original engine were of bronze-backed babbitt: generator-shaft bushing, lower main bearing, upper main bearing, master-bearing bushing. The knuckle-pin bushing and piston-pin bushing were of bronze. Steel-backed babbits were used in pinion-shaft bushings.

Inspection showed that the bronze-backed babbitt had started to separate at the bonding plane. So all upper-main bearings were changed to monometallic aluminum. Late in 1951, same trouble appeared on original lower main and master-bearing bushings. These were also changed to aluminum. After this experience, later engines were factory-equipped with all aluminum bearings.

Master bearings of steel with bushings were used in the 11-cylinder engines. In the 12-cylinder engines, a one-piece master bearing in aluminum Alloy *B* is used. Crankshaft and knuckle pins operate directly in the 550-lb casting rotating at 400 rpm with no noticeable wear.

Bearing alloys. About 85% of bearing alloys marketed by our firm are known as *Alloy 750*. These are usually furnished as full, permanent-mold castings in form of hollow cylinders.

Typical characteristics of alloys *A* and *B* are: yield strength; *A*, 16,000; *B*, 20,000. Elongation percentage 2-in. gage length; *A*, 8; *B*, 5. Brinell-hardness number; *A*, 50;



and other aluminum bearings commonly used in many types of modern machinery

B, 70. Specific gravity; *A* and *B*, both 2.88. Average coefficient thermal expansion, in. per in. per F (68F-392F); *A*, 0.0000135; *B*, 0.0000133.

Cold-worked temper of alloy *A* is generally used for engine bearings or other parts that are subjected to large differential expansion strains. Where the thermal strains are not great, such as bearings in an aluminum crankcase, the temper of *A* usually provides an adequate yield strength. Alloy *B* has greater resistance to thermal strain than alloy *A*. Now, let's take a good look at the advantages of aluminum bearings.

Long life. In testing life of conventional two-alloy or three-alloy bearings, versus aluminum bearings, latter are far ahead. This longer life pays you a big bonus at high speed or for heavy duty. It prolongs the interval between engine teardown and part replacement. Aluminum bearings are also free from scoring when they are properly engineered and installed.

Withstand higher pressures. Aluminum bearings have operated in breakdown tests from 200 to 300 hours at 4000 psi before failure, while steel-backed babbitt failed at 2500 psi after only 20 running hours. Three-alloy (steel-bronzed-babbitt), steel-backed cadmium nickel (0.029-in. thickness) and steel-backed copper lead (copper 55%, lead 45%), under maximum pressure of 3500 psi, ran 15, 20, and 50 hours, respectively, before failure.

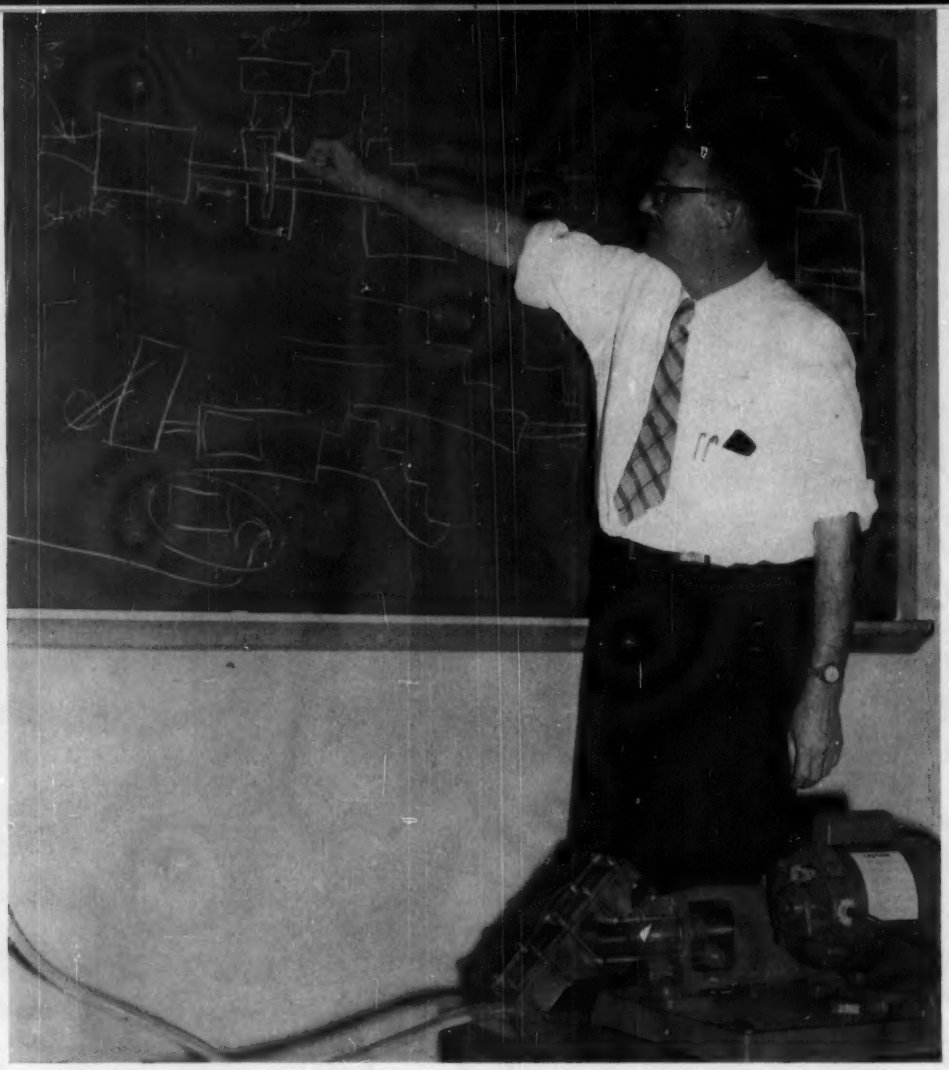
High fatigue strength. Aluminum bearings stand high resistance under fatigue because they have no bonding planes, as do two-alloy or three-alloy bearings. Being one piece makes them tougher.

High-corrosion resistance. Corrosive elements in oils may occur from compounds added to increase the film strength and oiliness of straight mineral oil. Solvent-type additives, to reduce carbon and varnish formations, can be corrosive in action with some metals. Breakdown products of the lubricants during operation can also be corrosive. Aluminum is free from corrosive attack, permitting safe use of oil additives without sacrificing bearing life.

High thermal conductivity. Aluminum has three to four times the heat conductivity of steel, and five times that of ordinary babbitt. Aluminum bearings don't have bonding planes to act as barriers to heat transfer. The very rapid spreading of heat in aluminum allows dissipation of local thermal risers before damage occurs. Heat is quickly transferred from inside bearings to outer surfaces.

Conformability and embedability. Aluminum is plastic enough to conform to ordinary misalignment. This plasticity allows for good embedability of dirt particles that might cause scoring.

No bearing surface to wear through. As aluminum bearings are made from metal of same quality throughout, rubbing surface cannot wear through to a layer of different material. This prevents shaft damage—a common fault in conventional-type bearings where more than one metal is used.



BLACKBOARD TALKS by author to users cover installation, adjustment and potential trouble spots

Want accurate, reliable controlled-volume pumps?

Then don't treat them as 'just another pump' when you plan the layout and make the installation. Here are the *do's* and *don'ts* needed to get the good results your pump can deliver

By B BERTOLET, *Service Manager, Milton Roy Company*

► CONTROLED-VOLUME PUMPS, also known as proportioning or metering pumps, are specially designed to deliver very definitely controlled volumes of liquids per unit of time to a particular point. Let's take a good look at them, how they're constructed, how they should be installed and how we can keep them on the job.

Basically, they consist of a plunger that reciprocates in a displacement chamber connected, through valves, to suction and discharge sides. Some pumps use a diaphragm between displacement chamber and the liquid to be pumped, but the most common type has a suitably packed stuffing box to seal the chamber. The latter is the one we'll discuss here.

Installation must be right if the pump is to do a good job. A controlled-volume pump is an instrument, a rugged one to be sure, but, like most instruments it needs the right installation and

A trouble-shooting chart speeds repair in emergency breakdown

SYMPTOM	CAUSE	REMEDY
Pump won't operate		
	Blown fuse	Replace fuse
	Starter thermal-overload device open	Reset
	Low liquid-level cutoff function	Fill suction tank
	Broken wire	Locate, repair
	Low voltage	Determine reason
	Liquid "frozen" in pump	Thaw out
Doesn't deliver rated capacity		
	Starved suction	Increase suction head or pipe size
	Suction leaks	Eliminate leaks
	Suction lift too high	Reduce suction lift
	Liquid too close to boiling point	Subcool liquid or raise suction pressure
	Wrong stroke adjustment	Correct adjustment
	Leaky packing	Adjust or replace
	Wrong speed	Check line voltage, frequency against motor nameplate
	Worn, dirty valves or seats	Clean or replace
Erratic delivery		
	Leaky suction or packing	Repair or replace piping, packing
	Worn, dirty valves or seats	Clean or replace
	Low suction pressure	Increase suction pressure
	Liquid too close to boiling point	Subcool liquid or raise suction pressure
	Leaky relief valve	Repair or replace
Motor overheats		
	Power doesn't match motor characteristics	Check power supply against motor nameplate
	Too little, or wrong lubricant in gear case	Check lubricant level and type. Replace if doubtful
	Overload. Pump operated above rated capacity	Check operating condition against mfr specs
	Wrong lubrication or too tight packing	Adjust packing, check lubricant type
	Overall wrong lubrication for pump	Check all lubricating points
	Mechanical misalignment	Check alignment of all working parts
Noisy operation		
	Pump valves	Normal clicking and rattling sometimes amplified by natural resonances in piping system. Generally, no cause for alarm
	Loose rod bushings	Replace worn bushings and pins if necessary
Gear reducer		
	Gear backlash	Adjust or replace gears
	End play in high-speed shaft	Shim shaft
	Worn bearings	Replace
	Wrong type or lack of lubricant	Drain, refill gear case with proper lubricant

startup procedure. About 75% of calls we get for help come from people who have just put a pump into service. It's significant that in about 95% of the cases the trouble results from some violation of good installation or startup practice.

Pump location and piping layout is important. These factors can't be covered by an instruction book. Nor can a book control the thinking of the piping-layout draftsman who, perhaps 2000 miles away from the job, doesn't bother with basic installation practice. "After all," he says, "it's just another pump."

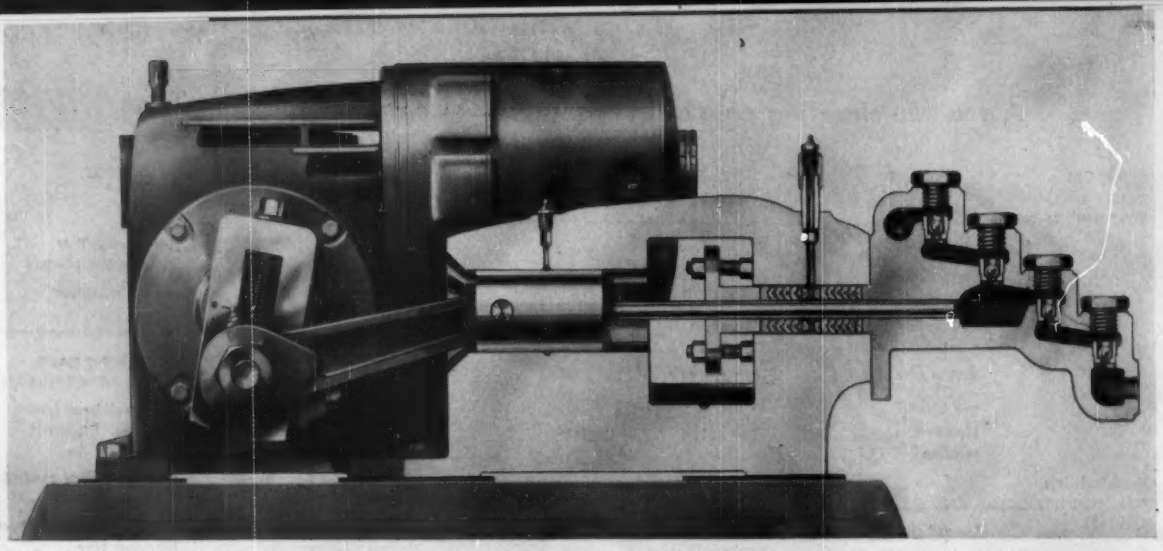
General design of controlled-volume pumps makes it obvious that they should be firmly secured to a solid foundation, preferably a concrete pad, of adequate size and high enough to protect the pump's drive mechanism from becoming flooded when the area is washed down. Too, the pump should be located to allow easy maintenance. Piping to and from the pump should be well supported to prevent misalignment of the pump assembly.

Suction-line importance can't be emphasized too strongly. Purpose of this line is to supply the pump with liquid under sufficient absolute pressure so the displacement chamber will always be filled at the end of the suction stroke. If possible, the pump should have "flooded suction," that is, the liquid level in the source tank should always be above the pump's suction fitting. Pumps, in certain sizes, will operate satisfactorily with suction lifts of up to 20 ft of water. But maintenance becomes a problem in these cases because even slight leakage in suction piping, or at the pump's stuffing box means erratic operation.

Further, the suction-line material must resist chemical attack of the liquid being pumped and the line should be as short and direct as possible. It should be big enough to prevent any appreciable pressure drop at the pump. *Maximum instantaneous*, not the *average* flow rate is the design factor in sizing. The pump's suction fitting is big enough to give maximum flow, but it shouldn't be used as a guide to suction-line sizing.

Suction connection at the source tank should be a couple of inches above the bottom of the tank to give a settlement zone for undissolved particles of solid chemicals, sludge, etc. This is particularly important with low-capacity pumps—30 gph or less. Avoid trouble by setting up a means of draining and flushing the source tank settlement zone. Suction-line strainers are added insurance if there's dirt or other foreign matter in the solution.

Tubing, rather than pipe, should be considered for the suction line. Its smoother interior and its ability to form sweep bends reduces pressure drop—



CUTAWAY of liquid end shows stuffing box and unique step-valve assembly. Pressure differential must be positive across pump

important where the liquid handled is of high vapor pressure or high viscosity. Here, pressure drop means flashing or cavitation. Either causes erratic operation. Flashing is instantaneous boiling; cavitation is the failure of the liquid to follow the motion of the plunger in the displacement chamber, causing cavities or voids.

Where a long suction line can't be avoided, surge chambers installed in the line next to the pump can hold down pressure drop. The surge chambers are exactly like those used with reciprocating pumps to smooth out the discharge, except here they're put on the suction side and provide a positive head to immediately supply pump's suction demand.

If the job means handling liquified gases, such as carbon dioxide, Freon, etc, it may be necessary to subcool the liquid to avoid flashing caused by pressure drop on the suction stroke. And, with viscous liquids, it's sometimes necessary to up suction tank pressure with air or inert gas when atmospheric pressure can't make the liquid flow to the pump.

Now, let's take a look at the discharge piping. As with all positive-displacement pumps, if the discharge line is blocked—and there's no relief device, or one that doesn't work—something has got to give. Controlled-volume pumps, even in small sizes, can develop mighty high pressures in a closed system and the discharge piping must have a dependable relief valve or rupture disk. If a rupture disk, make sure it's rated from both pressure and temperature standpoints, and that it's the right material for the service.

Relief device discharge outlet should be led to a point of safe disposal of the liquid being pumped. Generally, it's

Good layout, right startup method—

Keys to controlled-volume pump life

brought to a drain or the source tank and set up so relief device leakage will be visible. This is important because even a small leak might be a large percentage of the capacity of a small pump.

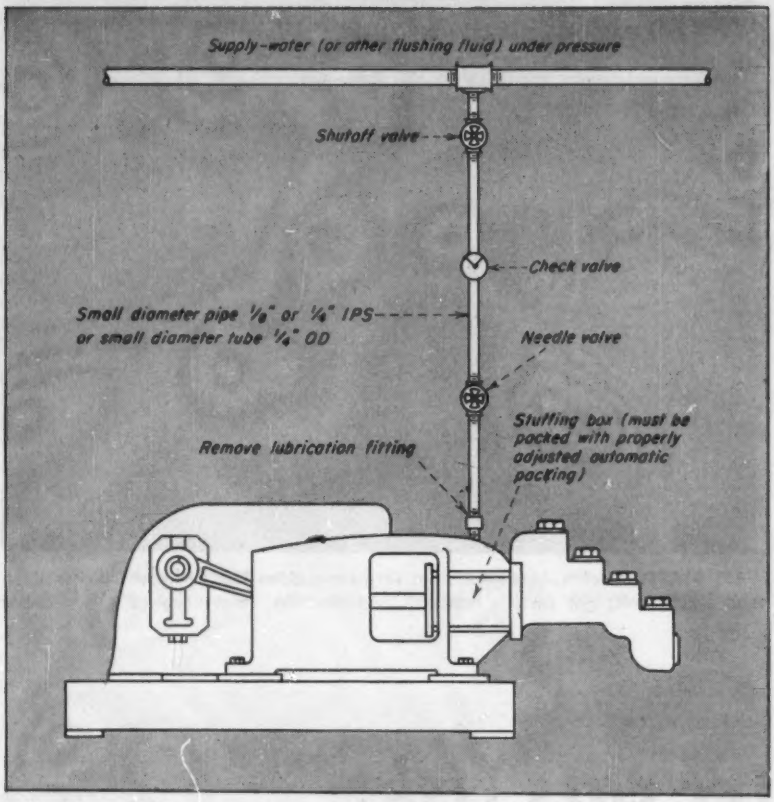
Sometimes the relief device is part of a closed loop that comes back to the suction line. If so, the connection to the suction line should be on the tank side of any suction-line shutoff valve to permit isolation of the pump.

Thermal overload devices, or pressure switches in the motor circuit don't function quickly enough in an overpressure situation. In a hydraulic system that's completely filled with liquid, addition of just one more drop will theoretically raise the pressure to infinity—so the relief device must act instantly when it senses overpressure.

Coming back to pressure drop for a moment, the discharge line must be big enough to handle maximum instantaneous flow from the pump. The pump will raise pressure enough to force the liquid through a too-small pipe, but it does so at the expense of excessive wear-and-tear on the pump's drive mechanism.

A positive pressure differential must exist across the pump for positive seating of the free ball-check valves to get accurate metering. If suction pressure is higher than discharge pressure, liquid would flow through the pump even if it wasn't in service. This could happen, for instance, if the suction tank was on the third floor of a building, the pump on the second floor, with discharge to an open mixing tank on the first floor. There is a way to handle a situation like this, but it takes special equipment and should be avoided.

Some services, such as handling highly abrasive slurries, or liquids of limited solubility cause deposit of abrasive crystals in the stuffing box. To get around this, it's a good idea to specify that the new pump be fitted with a stuffing box flushing system. Two types generally used are: (1) The through flush, in which water or some other satisfactory liquid enters one side of the stuffing box, flows through the lantern ring and out from the other side to waste. (2) The internal flush, in which the flushing liquid (part of that being pumped) enters the stuffing box under slight pressure and returns to the pump in the following manner: The discharge stroke forces some of the liquid into the packing. On the suction stroke, displacement-chamber pressure drops to suction-line pressure, packing relaxes


Supply-water (or other flushing fluid) under pressure
Shutoff valve
Check valve
Small diameter pipe 1/8" or 1/4" IPS or small diameter tube 1/4" OD
Needle valve
Stuffing box (must be packed with properly adjusted automatic packing)
Remove lubrication fitting

STUFFING BOX flush system means less packing wear when pumping abrasive slurries

slightly and a small amount of flushing liquid flows up through the stuffing box along the plunger. It's effective in keeping the stuffing box clean and gives best results when vee or chevron packing is used.

Some pumps designed to handle highly corrosive chemicals, such as sulfuric, nitric, or hydrochloric acids, or ferric chloride, have a so-called "catch-all" gland. This special gland has a cored-out well to catch stuffing box leakage. A tapped opening drains the internal well.

Safety is the order of the day during installation. Remember, in all probability the pump will handle a hazardous liquid, so system layout and actual installation calls for clear thinking. Perhaps the most important thing to keep in mind is that this is a positive-displacement pump and pressure in a closed hydraulic system can rise very fast.

Installation completed, we arrive at the critical startup period. Many times, people who take over the startup haven't had anything to do with the installation. This is where it pays to make a toothcomb check of suction, discharge, flush, electrical, and any special connections. Be sure there's no dirt, compound, etc, in the suction and discharge lines. The only way to do this is to flush the lines. Check plumbing for tightness. Check location of valves, switches, etc, for possible emergency operation. Be sure the relief device is the right one—and in the right place. Check all foundation bolts and the bolts on the pump assembly.

Gear reducers on these pumps need special lubricants. Generally, they're worm or combination spur and worm reduction. They have high ratios and generate a lot of heat. Some reducers have the right amount and quality of lubricant in them when they're shipped from the manufacturer, some are shipped dry. Don't operate the reducer without checking this. Each gear-reducer manufacturer has his own lubrication specification which should be strictly followed.

The pump may have been shipped from the factory months or even years before actual startup. Maybe it's been exposed to extremes of temperature and humidity. If there's any chance of this, drain and refill the gear case. Certain additives in these oils break down when they absorb moisture and when they are in contact with polished metals during long storage periods.

Moving parts—connecting rods, crossheads, etc,—generally have grease fittings, though some pumps are oil-bath lubricated. Follow pump manufacturer's lubrication instructions. Stuffing boxes, when flush systems aren't used, need special lubricants because a lot of friction develops between plunger and packing. Ordinary cup greases are attacked and made useless by the solution being pumped. If you're using the recommended stuffing box grease be sure to check with the manufacturer when you start handling another liquid. It is quite likely you'll need a different grease. Another tip: Before start-up, completely release the packing gland, then pull it up just finger-tight.

Experience proves, especially in fractional horsepower sizes, that before using the pump the stroke should be adjusted to zero and the motor operated for 10 to 15 minutes. This thoroughly distributes the gear oil through the bearings, gear faces, etc.

Water test the pump, if possible, before you start pumping the chemical solution. With water, you can test the entire system without hazard. To do this, fill the suction tank with water to a point above the pump's suction connection. Open the pump's suction valve. If you've reduced stroke to zero, as suggested above, reset it to about 1/3 full stroke. With a plugged tee in the discharge line (recommended as a permanent setup for startup and test), you can close the discharge valve and remove the tee plug. Operate the pump with a free flow from the tee for about 10 minutes. Then increase to 2/3 stroke and operate for another 10 minutes. Finally, increase to full stroke and operate this way for 10 minutes. If the pump has a flush system, the flush should be on during the test.

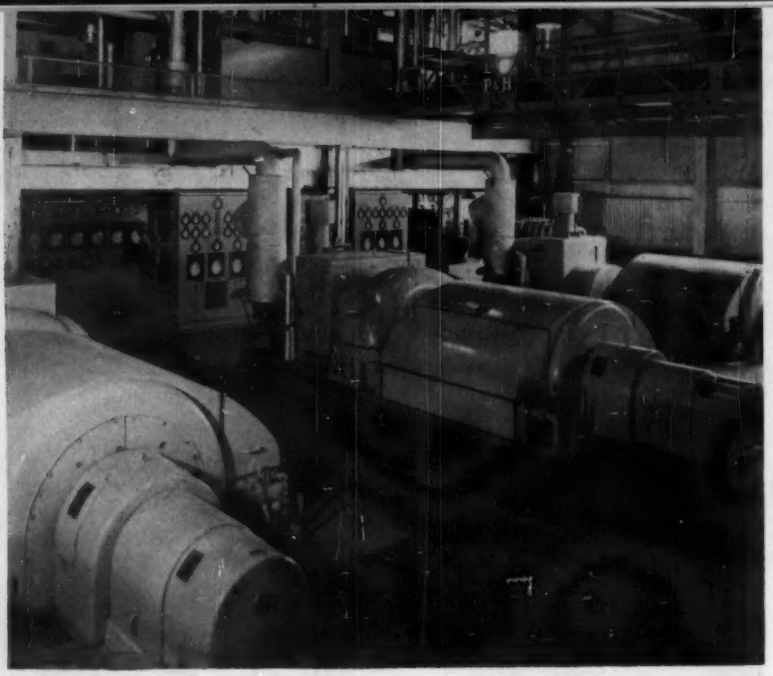
After completing the pump test, replug the tee, open the discharge valve and put the pump on the system. Stroke can be adjusted for desired chemical feed and the system tested for leaks at the same time. Feed rate is proportional to stroke length, so it's easy to calculate stroke setting for the desired feed. For instance, if pump rated capacity is 30 gph at 3-in. stroke, we get a 25-gph delivery with a stroke setting of about 2½ in.

Capacity ratings, with most pumps, are based on pumping water at room temperature. Ratings range from about 85% of theoretical capacity in small sizes to about 95% of theoretical capacity in the larger sizes. Such derating allows for unknown factors when pumping liquids other than water.

With pump and system testing satisfactory, the pump is ready to go to

(*Continued on page* 198)

By **ARNOLD FEATHAM**
Engineering Laboratory and Research Dept
The Detroit Edison Company



FAST STARTING of turbine-generators to meet sudden load increases invites damage unless units get smooth handling. Acceleration indicator gives safety factor

Accelerometer cuts risk, helps turbines start fast

Ever have to bring a turbine-generator up to synchronous speed in a hurry? Here's how we do it with an acceleration-indicator and speed-recorder assembly we built in our plant

► ENGINEERS KNOW that getting a turbine-generator on the line fast is a touchy business. Load increases often make it necessary to start a unit and bring it up to synchronous speed as quickly as possible. And, if it isn't done just right, it's easy to damage the unit.

The operator is a busy man, with many things to watch when faced with this job. In our plant, until recently, the only help he had in setting the steam-admission valve for correct acceleration was the speed indicator mounted on the turbine.

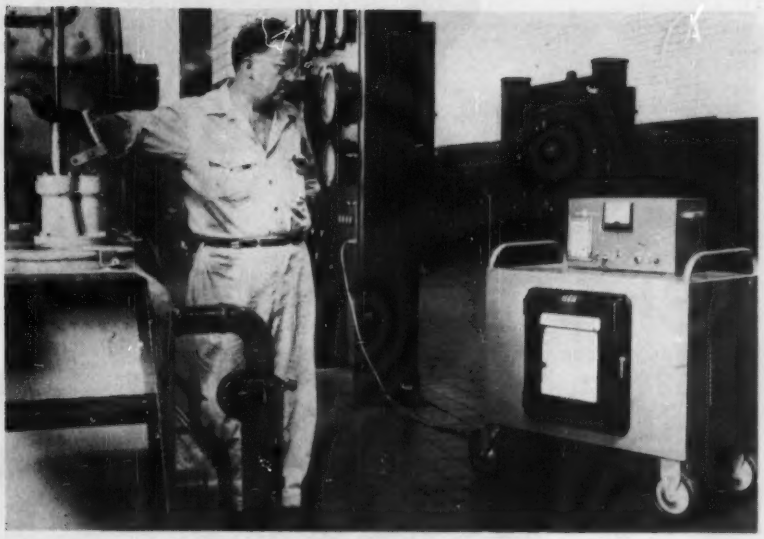
To set the valve by watching the indicator is difficult because a speed change during a minute's interval has to be noted mentally. Changes are small and hard to read, and many times there's apt to be a considerable delay before the operator can start any necessary corrective action. First correction is likely to be too much or too little and several minutes go by before he gets the right setting. Any later change from this setting gives the same trouble.

At our Conner's Creek Plant, we hunted for an answer to this problem. Since this is the age of the "electronic brain," we believed the solution would be an instrument that would do the operator's computing and give him a continuous indication of acceleration. A glance at the instrument would tell him how to set the admission valve.

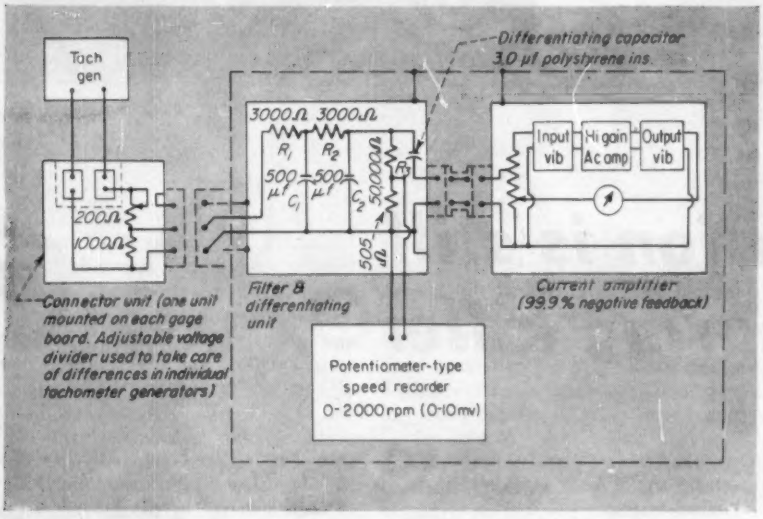
We built an experimental acceleration indicator designed to do the job we had in mind. It worked very well and, as a result, it's now much easier to carry out several "quick-start" procedures. One is for a unit that has been shut down over night, another's used after a week-end shutdown, and a third for after an overhaul. *Example:* After a week-end shutdown, a unit should be brought up to 400 rpm in five minutes, or 80 rpm per minute. After five minutes at 400 rpm, it should be brought up to 1800 rpm at 40 rpm per minute. Our acceleration indicator helps us to do exactly that.

Basically, the indicator is similar to one of the most important units in an analog computer—the feedback amplifier-type differentiator. This unit supplies an output current proportional to the time rate-of-change of a voltage applied to its input.

With our indicator, we take a voltage representing speed from the tachometer generator used with the regular speed indicator. The differentiator section of our instrument calculates the rate of change of this voltage and gives an output representing acceleration, shown on a meter scale. In addition, since we don't have individual speed recorders on the turbine-generators, we built a speed recorder into our instru-



ACCELERATION-INDICATOR and speed-recorder assembly, mounted on caster-equipped cart, allows plug-in to connector at individual turbine-generator gage board



SCHEMATIC DIAGRAM shows tie-in from tachometer generator through gage board to filter, differential capacitor unit and to speed-recorder and amplifier-units

ment assembly to give us a record of the procedure followed, photo p 131.

Schematic diagram, above, gives a general idea of the method. Output voltage of the tachometer generator on each turbine comes to the connector unit on the gage board. Each connector unit has a receptacle that takes a cable from the portable acceleration-indicator and speed-recorder assembly. The cable ties into the filter and differentiating capacitor unit. From this, connections are made to the speed-recorder unit and amplifier unit, which has an output meter calibrated to show acceleration. As the schematic shows, these last three units are assembled on a caster-equipped cart. Photo shows the amplifier on top of the cart, the recorder mounted below.

Tachometer generators are dc, but have only two-segment commutators. They're driven through a reduction unit at about one-quarter of the turbine speed. *Result*: Output is a pulsating voltage which may be thought of as a dc component with a large, low-frequency ac component superimposed on it. Magnitude of the dc component varies linearly with turbine speed up to a value of about 1.3 volts at 1800 rpm. The ac component has a peak value almost equal to the dc component and a frequency of about 15 cps at 1800 rpm. At 120 rpm, frequency is only 1.0 cps.

Each turbine gage-board connector unit takes leads from the corresponding tachometer generator. Since the output of a particular generator may differ considerably from the approximate value of 1.3 volts at 1800 rpm, we added an adjustable voltage divider so we could set the voltage, after passing through the filter, at a standard value of 0.9 volt at 1800 rpm.

Filter unit serves to get rid of as much as practicable of the ac component of the tachometer voltage without seriously affecting the desired dc voltage to be applied to the acceleration indicator. Presence of the ac component would cause large fluctuations in indication and make our instrument useless. The filter is a two-section resistance-capacitance, or R-C type, and does a good job though it will allow a small fluctuation of indication at low turbine speeds. If we had tachometer generators with more commutator segments, our filter design problem would have been easier.

With the filter taking out most of the ac component, we get a dc voltage proportional to turbine speed. Next, to get the rate-of-change of this voltage to indicate acceleration, we chose an effective and commonly used capacitance method of differentiation. This depends on the fact that current through a capacitor is proportional to the rate of change of the voltage applied to it. To measure the current, we used a negative feedback-type current amplifier. This measures current, but the feedback circuit maintains amplifier input voltage at practically zero. In other words, current is measured without affecting voltage across the capacitor.

Maximum rate-of-change available for the differentiating circuit depends on two factors: (1) Filter output voltage, which in this case is 0.9 volt at 1800 rpm. (2) Desired full scale reading of the acceleration indicator, which we chose to (*Continued on page* 210)

CORRECTION

In POWER, November 1956, p 115, first word in next-to-last line of first column should be *pulling*, not *pulls*.

LUBRICATION FIELD NOTES: 1

Almost every article on motor lubrication underlines pitfalls of too much lubricant.

But Sim Jester, lubrication engineer with Gulf Oil Corp, points out that overlubrication is still a weak spot in plant maintenance. Here, in the first article of a series on practical lube problems, he says . . .

Overlubrication is still a motor-bearing killer

► "YOUR GREASE is no darn good," yelled an excited voice at the other end of my phone. "It burned out bearings in the motor that drives our only air compressor. Now we've got no air supply, and no automatic control for our production machines. Our whole plant's shut down. What kind of grease you giving us anyway?" roared the superintendent.

Calls like this are not infrequent. All too often the customer picks on the lubricant first when a bearing or gear field problem crops up. It's my job, as a field lubrication engineer, to discover the real trouble and correct it. Here's what I found in the plant mentioned above:

They had already replaced the ball bearing when I arrived. The one removed was all gummed up. As the superintendent put it, "neither gasoline nor kerosene would clean it." I pointed out that mineral spirits or Stoddard's solvent would be a safer and more effective cleaner.

There were ample signs of excessive heat; you couldn't turn the bearing's inner race. I suggested a look at the compressor. It was driven through a multiple V-belt, with an overhung pulley on the motor. Whole unit was crowded up against a wall in a narrow passageway. Bearing on the V-belt side of the motor had failed, and the one they'd just installed was running hot.

I scraped my finger under winding side of the bearing and got a walnut-sized lump of grease that had been forced out. Its color and consistency were normal, indicating grease in excellent visual condition. But the relief plug under bearing was untouched so any excess grease came out through the bearing closures.

Electrician said he first packed the new bearing by hand. After assembly he forced more lubricant in with a grease gun. Schedule called for regreasing once a month.

I'd seen enough to convince me the bearing suffered from overlubrication and, if given half a chance, the grease would be entirely satisfactory. Bearing on the back end of motor was OK. Although not as heavily loaded, it didn't get all the babying because it was simply harder to reach.

Why bearing failed. The bearing failed because it was killed with kindness. Initial over-greasing packed it solid. When it turned, grease was whipped up, generating excessive heat and pressure. Some grease was forced through the seals, but pressure was still maintained within. Overheating and mechanical working prematurely disintegrated the grease. Frequent regreasing repeated the destruction cycle.

Meet the author

In twelve years as a lubrication engineer, Sim Jester has solved many lube problems. His work with the Product Application Department of Gulf Oil Corp takes him into all kinds of industrial and power plants. He prepares lubricant recommendation charts, advises on plant practices, sets up oiling procedures and investigates complaints on the use of oil and grease.

Before joining Gulf seven years ago, he did similar work for Shell Oil Company.

His background also includes a year as boiler designer with Combustion Engineering, Inc, and five years with American Engineering Company, designing, applying and selling hydraulic pumps and related equipment. He received his engineering degree from MIT, gained his first practical engineering experience in ship engine rooms.

A member of the American Society of Lubrication Engineers, Sim is making lubrication his life work. The incidents and down-to-earth solutions presented in *Lubrication Field Notes* are all based on experience.

Proper lubrication with the right amount of grease would have permitted adequate expansion within the housing. With the excellent grease they were using frequent relubrication was unnecessary, and in fact caused trouble. It was a case where a little was enough, more was too much.

My recommendation was to grease the bearings once every 4 to 6 months. This is often enough when the motor is properly aligned. The superintendent threw up his hands. He said they couldn't chance a bearing failure. Nor could they remove the relief plug to let out old grease and relieve excess pressure. This was too much to ask in the crowded space. I warned that they were in for more trouble if they kept on packing in so much grease.

We finally hit on a solution. Superintendent agreed to remove the relief plug and hang a small can underneath to catch excess grease. Then maintenance man could grease the bearing whenever he wanted, but pressure couldn't build up to generate heat. This also removed danger of grease being forced up the shaft towards the motor windings.

Good practice. In a large Eastern brewery I noticed the complete absence of fittings on all grease-lubricated motors. The plant's regular oilers said they didn't touch the motors and referred me to the electrical department. I learned that motors were carefully hand packed with a high-quality grease during overhaul and plugs were used in place of grease fittings. Once a year the electrical department properly greased all motors that hadn't been overhauled in that time. Had this procedure been followed the bearing failure previously described would not have occurred.

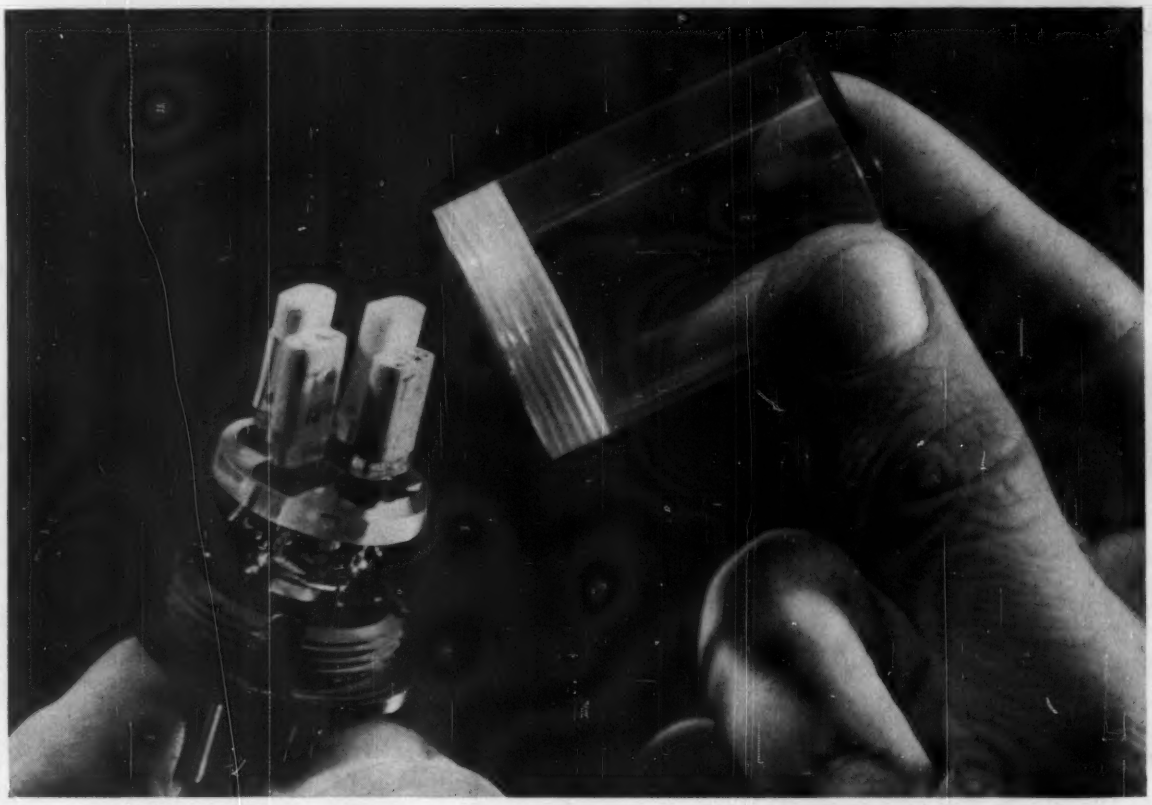
Careful precautions can't protect equipment from the clutches of the fellow who has more brawn than brain. I spotted one of these characters in the maintenance shop at a large brass mill. The new lubrication supervisor was in a remote part of the plant and I waited in the shop office while they located him. I could see most of the shop through the windows. In a back corner, men were overhauling a large motor-driven blower. One man began to grease the motor bearings. At least they were doing it while the motor was running.

My attention was distracted for a minute or so. When I looked back the man was still at it, pumping grease steadily into the same bearing. Every once in a while he looked to see if it was coming out anywhere. I assumed he'd removed bottom relief plug and was "flushing" the bearing—not exactly the most effective way to do it.

He was using a grease gun that held about 12 oz—enough for a dozen or more such motors. But he had to refill it since he had pumped all the grease into one bearing. Armed with a freshly loaded gun our grease boy hooked onto the other bearing and this time I counted his strokes. I could hardly believe my eyes as I watched him pump 52 strokes of grease into that one bearing which couldn't have been more than 4 in. OD. This plant had called us in previously to make suggestions for improvement of lubrication conditions, and here was a fine example of what not to do.

When the lubrication supervisor arrived, I told him what I'd seen. We looked at the motor. Much to my surprise the relief plugs were intact and showed no signs of having been removed. Unfortunately, outboard bearing seals had held up under this terrific pressure and there wasn't a sign of excess grease on the outside. No

(*Continued on page* 212)



FOUR JUNCTION TRANSISTORS mounted on small plug-in base replace two or more tubes and other amplifier components

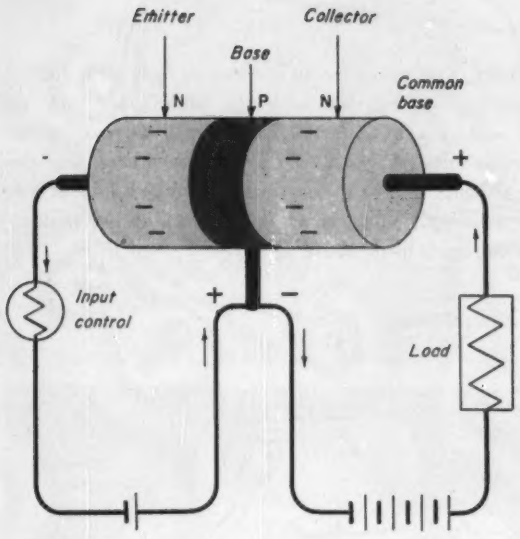
Transistors have established a fine reputation in communications and computers. Soon you'll meet them in industrial control.

What you should

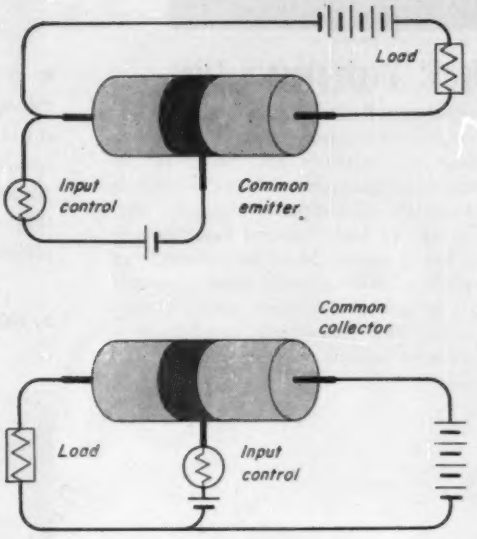
► AT PRESENT transistors are being used only for some of the trickier control tasks, but if they perform as expected you'll probably see these versatile midgets used in place of more familiar components in a wide variety of controllers. Transistors are used exclusively in place of electron tubes in a steel-rolling-mill control designed by General Electric and U.S. Steel for latter's Irvin Works at Dravosburg, Pa. The regulating system that controls sheet-steel thickness in the high-speed cold reduction mill combines transistors with magnetic amplifiers to get rugged, dependable units needing little or no routine maintenance. System was put into operation more than a year ago. Other companies are active in developing transistor applications.

Transistors can be put to work wherever it's advantageous to amplify a control signal. Because they're more rugged and more reliable, they'll probably replace electron tubes of present controllers and will be used in new applications where designers would hesitate to use tubes because of vibration or other adverse conditions. *Example:* Operating relays from photocells, thermocouples or directly off instrument shunts. Power capacity of transistors is increasing (now available with 60-w internal dissipation) and they'll be suitable for motor loads driving rheostats, tap changers, etc. They can handle larger loads when used with magnetic amplifiers. Promising future for transistors is with precise dc motor speed control in conjunction with rotating amplifiers such as amplidynes and rototrols. It's even possible that power of transistors will soon be great enough to control exciter or generator fields directly. Simplicity, reliability and quickness of response are all in their favor. At present cost, power limitations and restricted operating temperatures are chief stumbling blocks.

What is a transistor? Certain elemental substances, for example, germanium, are called semiconductors because under some conditions they conduct electricity and under other conditions they don't. Typical transistor for industrial control is the junction transistor, sketch, p 135. It's made of three sections pressed together; two sections of *n*-type germanium with a section of *p*-type germanium between.



JUNCTION TRANSISTOR in common-base circuit. Weak input signal is amplified to operate a relay or controller motor



TWO CIRCUITS used for amplifiers. Each has special characteristics that recommend it for a particular control job

know about transistors

The germanium from which transistors are made is first refined until it is very pure. Then minute, carefully controlled quantities of another element are added to produce the different properties of *n* and *p* germanium. To fully understand the difference between *n* and *p* germanium requires a pretty thorough knowledge of electronic theory, but roughly it is this: *n* germanium behaves as though it had *negative* properties, that is, it tends to give off electrons, while *p* germanium acts as if it has *positive* properties, or tends to absorb electrons. (Refer to *Basics*, POWER, Aug 1956, p 148.) Because action takes place at adjoining surfaces of *n* and *p* sections, combination is called a junction transistor. (It's possible to make *p-n-p* as well as *n-p-n* junction transistors.) The germanium sections are very small. Units shown in photo, p 134, small as they are, consist mostly of a hermetically sealed jacket that surrounds the germanium.

How transistors work. Junction or "barrier" between sections acts as rectifier under normal conditions; current will flow from *n* to *p* but not from *p* to *n*. A direct current can flow from emitter to base (in common-base circuit, at left in sketch) if connected in circuit with correct polarity. The input control in this circuit is the photocell or other device that originates the signal. If input circuit is open, load-circuit current can't flow because it is blocked by the *p-n* barrier between the base and the collector. When input current flows through the *p* section, however, it changes the nature of the *p* section so that current in the load circuit can flow through the *n-p* barrier. Thus, the transistor acts like a valve, with the load being a relay coil, motor winding or magnetic amplifier. Currents in input and load circuit are about the same, but load circuit voltage can be much larger than input circuit voltage. With constant current, power (EI) is proportional to voltage, and amplification of 2000 times or more is possible.

Two other circuits are frequently used, the common-emitter and common-collector, counterparts of electron-tube circuits. They make transistors adaptable to many control operations. A lot has to be learned about transistors for industry, but their advantages are sure to increase their use.

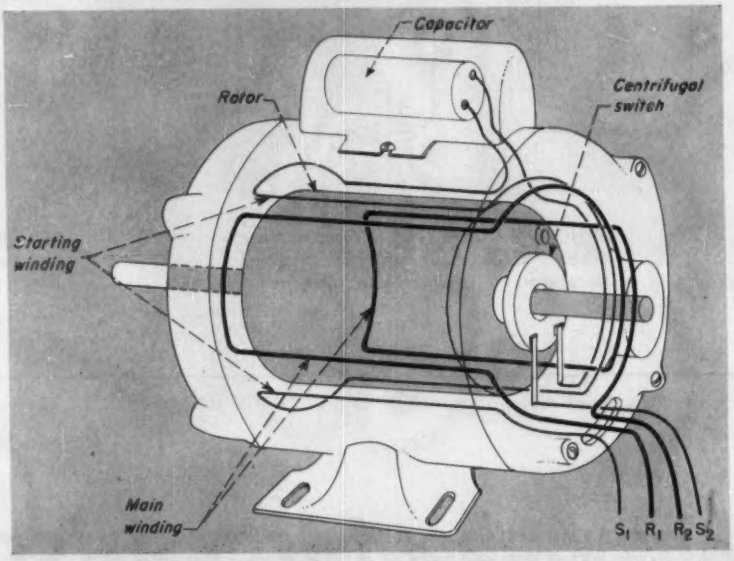
Plant Electrical Fact File

5 single-phase motor designs

No. 9: Single-phase motors

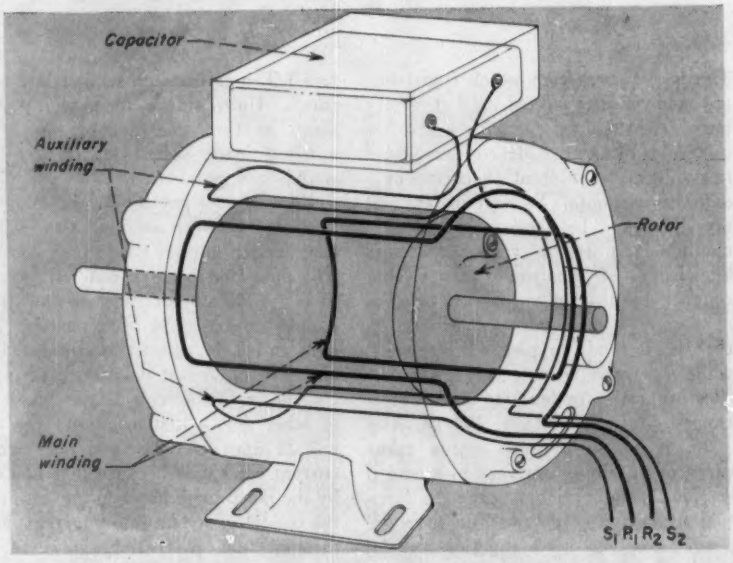
► SINGLE-PHASE MOTORS, with exception of the series type, are induction motors. Induction motors will run fine on single phase once they are started—but it takes some tricks to start them. Chief difference in various types is the starting method. Each type has its advantages and disadvantages for any particular use, so its worthwhile to take a look at how they operate before selecting. Voltages are keyed to lighting and appliance circuits. Dual voltage is usual above ¼ hp.

By **NORMAN PEACH**, *Assistant Editor*



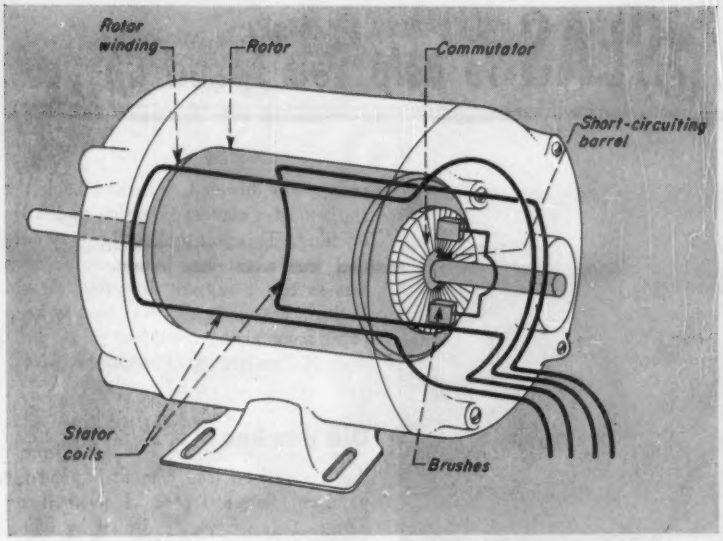
1

SPLIT-PHASE CAPACITOR motor is leading general-purpose type where good starting torque is needed. Capacitor in starting winding causes phase displacement, creates in effect a 2-ph winding during starting period. When rotor reaches about 80% of full speed, centrifugal switch opens starting winding circuit. Motors are reversed by interchanging connection of starting and running leads. Rotor must be stopped before it can reverse. Resistance split-phase type is popular where less starting torque is needed; starting winding is wound with small size wire to get higher resistance than running winding.

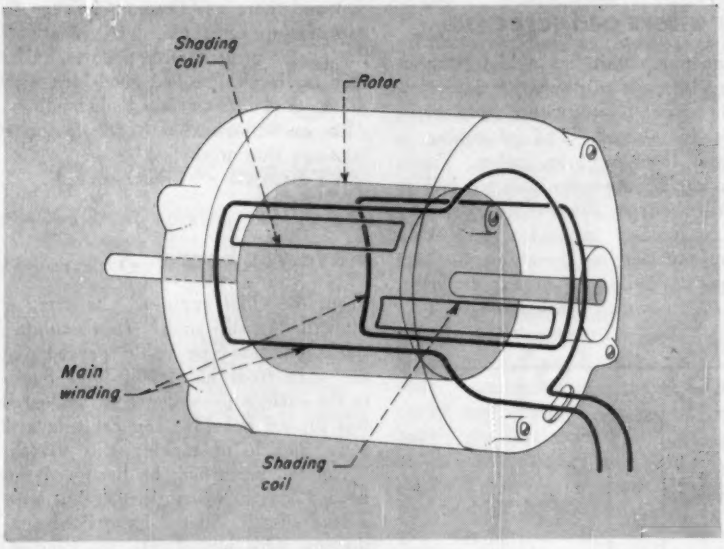


2

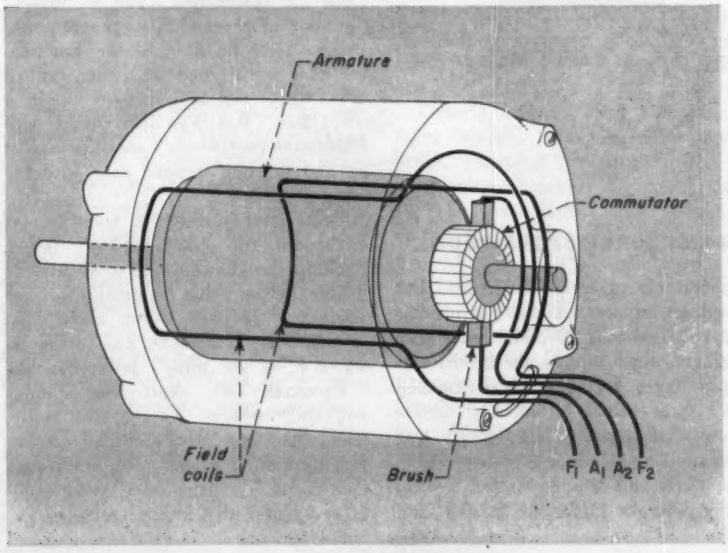
CONSTANT-CAPACITOR motor keeps winding with capacitor connected while motor is running. These motors, used mainly for fans, blowers and some control applications, have less starting torque than capacitor-start motors, but more than shaded-pole types. They're adaptable to multispeed operation and can be reversed while running. More expensive than split-phase motor of same size, they're generally under ½ hp, but can be made in larger sizes. Multispeed motors usually have special connections that change number of poles in windings, but smaller sizes can change speed by varying capacitance.



3 **REPULSION - INDUCTION** motors have wound rotors and brushes. Brushes are connected together to close rotor circuit. Motors have high-starting-torque characteristics similar to dc series motors, but are losing popularity for many uses as split-phase capacitor motors are improved. Of many variations, most common is repulsion-start induction-run type where commutator bars are short-circuited and brushes lifted by centrifugal mechanism when proper speed is reached. Some designs have squirrel-cage winding embedded in bottom of slots. Stators are usually 110/220 v. Shift the brushes to change rotation.

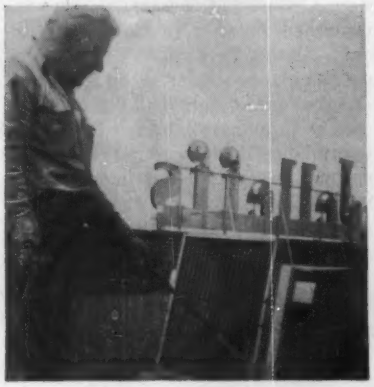


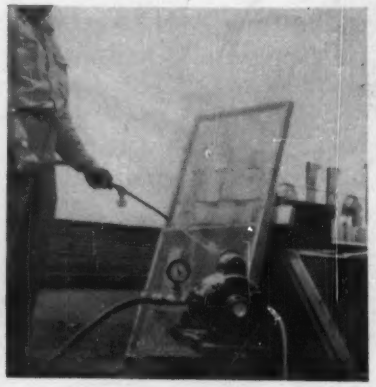
4 **SHADED-POLE** motors produce phase difference in motor's magnetic field by means of a coil, usually of one turn, around part of stator pole. Main winding induces current in shaded coil that lags current in main winding. Shaded-pole motors have low starting torque and high slip in speed. They're not reversible, but are often adapted to multi-speed operation by voltage control. You'll find them widely used for small fans and low-torque appliances. They're inefficient compared with other types, but in usual sizes this isn't as important as simplicity, lower price, ruggedness and need for little or no maintenance.



5 **SERIES MOTORS** for ac operation resemble their dc counterparts. They have wound armature, field coils, commutator and brushes all connected in series. Field core is laminated and turns are kept to a minimum to reduce inductive effects. When operable on both ac and dc they're called universal motors. They have high starting and running torque, but speed varies with load. This makes series motors excellent for portable tools; as load gets tougher, speed comes down and torque goes up. Reverse rotation, even under load, by interchanging connections: Connect A_2 to F_2 instead of A_2 to F_1.

Smart PRACTICAL IDEAS to help you speed up your





Quick, easy way to clean air filters and screens

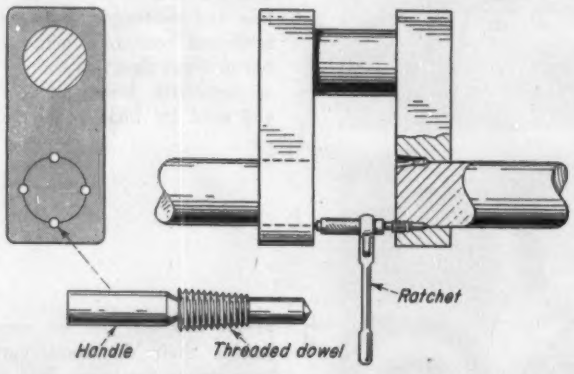
Most plants have air-filter cleaning problems. Return-air line at our store gives us trouble with lint. We solved headache by putting a screen over the return-air grills. Now we clean these screens every week, second photo.

Another problem was washing our roof filters where water pressure is low. But we solved low-pressure problem by using gear pump shown. Pump has up to 125-psi pressure at nozzle.

Our pump unit has a high-pressure hose with gage on discharge side. Nozzle is copper tubing with a ½-in. globe valve for shutoff. End of tubing is wedged down to ⅜ in. orifice.

In our beauty-salon unit we had to install Goodyear *Pliotron* filters as they can be washed in cold water. Also, because of location, these were the only filters we could use in our building.

W A Ludwig *Washington, D. C.*



12,000-acre rice crop saved by emergency crank-repair

Crankshaft of 300-hp diesel drove a 120,000-gpm irrigation pump at 200 rpm. Those old-time cranks were made by shrinking the crankwebs over the crankpins. Our trouble was that main crankshaft loosened and slipped in the web of No. 1 crank, sketch. This fault is not unusual with built-up crankshafts.

Usual repair was to drill into circumference of crank and web bore, then drive in tapered dowel pins. But I used an improved dowel pin on this job. I drilled four 29/32-in. holes with a ratchet, then tapped them with ¾-in. pipe tape. I made special threaded dowel pins, sketch. Pins had handle to screw in tight. Then handle was hacksawed and end peaned over.

As shaft had slipped in No. 1 web, timing of all injection nozzles and valves was out about 20 deg. After crank was doweled, I turned back the shaft to give correct injection and valve opening. This job took 48 hr—my only tool was a ratchet, but our rice crop was saved. I suggest doweling all old built-up cranks in this way just to keep them from giving trouble.

W R Pender *St. Petersburg, Fla.*

Did you know...

that *Smooth-on* iron cement is good for patching flange faces? I used it on flanges that were wire drawn by 850-F steam at 640 psi. That was two years ago and there has been no leakage to date. Before cement hardens, smooth off the excess cement with a putty knife, then file level. I've had good luck with this method on boiler handhole landings. Also on superheater handhole plate landings that were leaking badly.

A F Baptiste *Brooklyn, N. Y.*

Have you heard...

about the chief engineer who erred a bit with the slip stick? He calculated the submarine-type cable needed for the span from his 1400-ft-level pump to the surface powerhouse switchboard. But lo and behold! The cable lacked some 300 ft of making the stretch.

Not too perturbed, he borrowed the needed length, without armor but with a lead sheath. So the improvised conductors were pulled into the conduit. Then the splice was made by joining the ends in a jack-knife type of brass splice. After he finished the junction, the ends were taped well, then fanned out a little and laid midway up in a wood box. Box was then filled with *Chatterton* compound. Cover was nailed on and the box slopped over with hot compound.

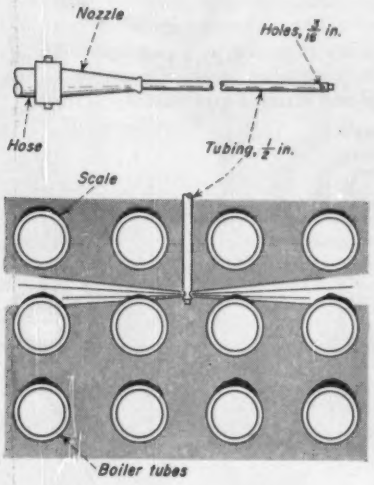
Years later, during the worst winter on record, the cable suddenly failed. Lacking the know-how of a wheatstone bridge, the boys dug frantically through many feet of hard frozen clay. That took a lot of overtime and worry as water filled the mine's lower reaches.

Eventually the short was found—you know where? Yup, at the splice, which had *not* been recorded. Splice was in a ditch where water infiltrated, then froze. Expansion allowed moisture to enter the 2300-v splice.

P C Ziemke *Oak Ridge, Tenn.*

operation and maintenance jobs

STEVE ELONKA, *Associate Editor*



This tube blasts scale

Cleaning waterside of tubes in some firetube boilers can be a headache. Washing these tubes can be especially tough because of tube's stacked arrangement. On such vertical rows, it's almost impossible to reach more than the upper and lower rows with a direct impact of stream from hose nozzle. *Reason:* Tubes in between are shielded from above as well as from below.

In these boilers, tubes act as shelves for sludge and loose scale. Deposits will eventually stick fast and form an insulating coat on hottest part (top) of each tube. Scale deposits cut down heat transfer and greatly reduce boiler efficiency.

You can make a very inexpensive and simple water lance, sketch. Use a ½-in. diameter brass or copper tube. Braze or solder tube to a hose nozzle. If nozzle is fitted with a standard pipe adapter, attach to a pipe nipple. Plug other end by soldering a ⅜-in. brass plug or rod into it. Then drill a 3/16-in. hole through nozzle at right angle. That will throw two streams of water across tubes, in opposite directions, blasting away sludge and loose scale with greatest impact.

For a 72-in. boiler, a nozzle about 5-ft long will reach down through tube nest. Use at least 100-psi water pressure for best results. Sweep lance back and forth between every row of tubes to wash entire tube surface.

This nozzle is easy to make and will more than pay for itself on first job.

A H MOULTON *Pittsfield, Mass.*

What would you have done?

Firm had designed and built a cracking furnace. Furnace was of brick, lined with firebrick and fired by gas. In it, connected by headers, were several 30-ft mild-steel pipes, 3 to 3½ in. diameter. Because 30-ft pipes could not be obtained in the regular market, these were made up of 20 and 10 ft lengths joined by ordinary screw joints in a sleeve coupling. The pipes were filled with a catalyst.

When in operation, a hydrocarbon oil (not crude petroleum, but a distillate) flowed into the lower header and rose vertically into the catalyst pipes. At 1800 F the catalyst would break down the oil into lighter, gaseous constituents that were used to enrich and augment the lighting company's gas service. Furnace was used only during emergencies and peak loads. To keep the furnace ready, it was held at 1200 F constantly, but no gas was generated. When demand peaked, temperature was raised to 1800 F at which point the catalytic breakdown took place. Following the peak, furnace was again held on standby at 1200 F.

Trouble began when the vertical tubes started to crack and finally break, dumping the catalyst into the combustion chamber. This meant loss of expensive catalyst and taking the furnace off the line until it cooled and was repaired. These breakdowns came regularly. There were other things wrong, such as flanged joints at the headers developing leaks, but tube failure was the big headache.

Analysis showed that a good seamless-steel tubing was being used. However, breaks all showed a brittle steel. What was wrong?

I spotted the 1200-F standby temperature as the main culprit. When casehardening steel in a hydrocarbon-gas-atmosphere furnace, temperature at which greatest carbon solution occurs is 1200 F. Thus, the standby condition was ideal for creating a high-carbon steel with a 1200-F constant-temperature soak and a pure hydrocarbon atmosphere inside the tube. High-carbon steel, so created, was brittle (not tempered). It had a low tensile strength at the elevated temperature and went through a heavy stress condition as the temperature was raised to operating performance; hence the failures.

I suggested replacing the screwed pipes with welded 30 ft lengths to do away with the bad joints. That would also hold standby temperature below that at which carburization took place, or below 1000 F. Tubes were replaced. Standby temperature was set at 900 F where no carbon absorption took place. Transition from 900 to 1800 F was to be made as rapidly as possible so that minimum carbon absorption would take place through the critical range. That solved the problem. What would *you* have done?

H M NEUHAUS *Philadelphia, Pa.*

Prevent electric shocks

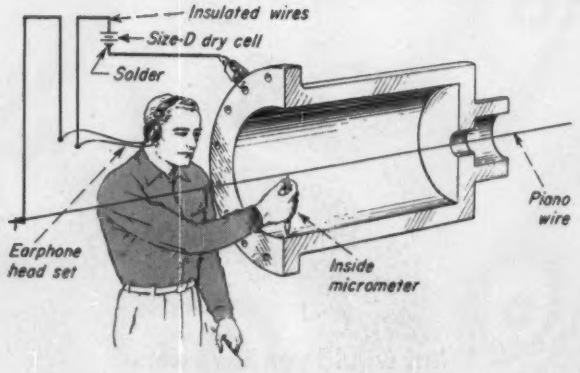
Tag and key chain, above, are attached to the plug prongs of an extension cord. Then no one can put plug into an electrical receptacle while electrician is working on the equipment. This gadget makes it easy to play it safe. It has proved very useful in our plant.

N KHO-RAFANAN *Cebu City, P. I.*

Turn page for more Practical Ideas ►

More PRACTICAL IDEAS

Begins on page 138

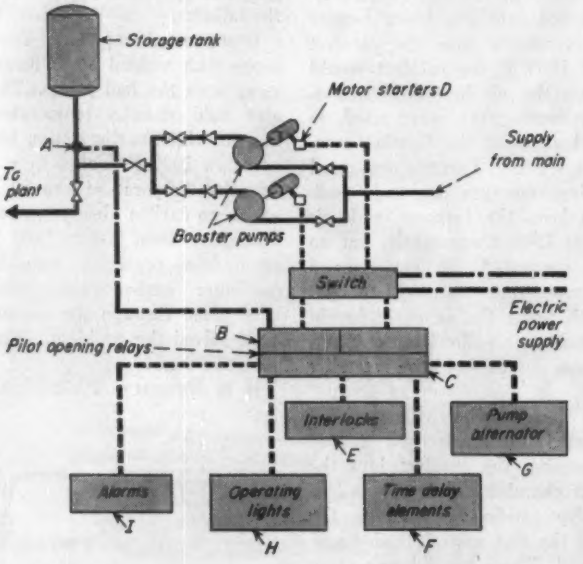


Here's your trick of the month

Here's a better way to line up tight wire for boring out old cylinders. As sketch shows, instead of depending on feeling the piano wire with micrometer, you hear the contact made. This works best when you use only size-D flashlight dry cell, as we always do.

By using small, well insulated electric wire and making connections tight, this method is accurate and will give static only on contact. Alignment stands shouldn't touch machine. If they do, you will have to insulate piano wire. Then you won't have to worry about short circuiting.

H STONE *Benton, Ark.*

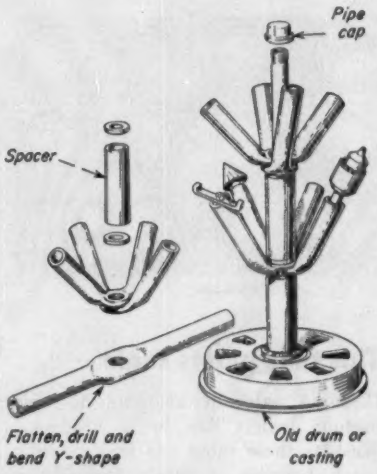


Here's what I would have done

On page 131, June 1956, J A Breen tells how he maintained pressure in a water-supply system. My sketch shows piping and electrical hook-up necessary for this type of installation. The design uses a pressure-sensing element *A* located in hydraulic circuit. Element actuates pilot relays *B* when the allowable pressure limit is reached. Pilot circuit energizes load relays *C* which open or close the pump's motor starters *D*.

Interlocks *E* compensate for friction loss changes resulting when different capacity pumps are used. Time-delay elements *F* prevent pump operation from surges. Other protective devices shut off the system when pump's suction pressure drops below safe limits, preventing damage resulting from dry operation. Automatic alternator *G* shifts sequence of pump operation to help equalize wear. Operating lights *H* and alarms *I* give warning of trouble.

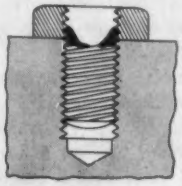
H B WAYNE *Woodhaven, N. Y.*



Tool holding Xmas-tree

You can make a handy Xmas-tree-type holder for tools from pieces of old tubing or pipe, sketch. Christmas tree keeps all tools in sight and reach, saves time and hunting. Holder is easy to make from scrap parts.

C H WILLEY *Penacook, N. H.*



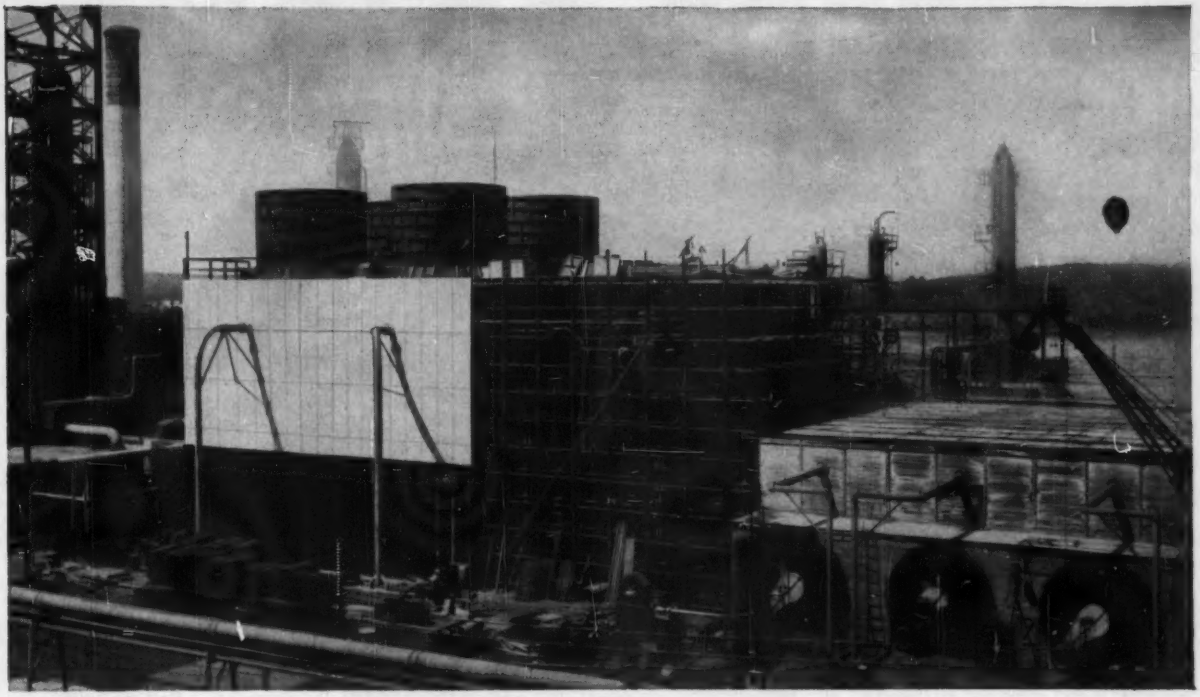
How to remove broken studs

Usual way to remove a broken bolt or stud is by drilling the bolt or stud with a small drill, then backing out with extractor. Better way is to electric weld a nut of slightly larger ID than OD of bolt or stud, over the bolt or stud, sketch. This gives a new head for wrench to turn. This method not only does away with re-tapping operation, but also supplies the heat needed to free frozen bolt or stud from its surrounding area. Try it next time.

N KHO-RAFANAN *Cebu City, P. I.*

Turn page for more Practical Ideas ►

MORE COLD WATER for D-X Sunray



New FW Cooling Tower replaces original forced-draft installation—gives 80% more cooling capacity on same foundation

A NEW eighteen cell Foster Wheeler induced draft cooling tower is shown at the left, above, during construction at the West Tulsa refinery of D-X Sunray Oil Company.

The tower was built in sections over the basin previously used for a Foster Wheeler forced draft tower shown at the right. New cells were put on stream as completed and the remaining cells of the old tower continued to operate until demolished. In this way the heat load was carried successfully through the summer without any shut-down during erection.

The new induced draft cooling tower, occupying the *same* ground area, has 80% more cooling capacity than did the original forced draft installation.

The high cooling efficiency, low drift losses and rugged, all-redwood construction of the completely new line of FW induced draft cooling towers mean lasting economy and dependability in year-round service.

For complete information, send for a copy of new Bulletin No. CT-56-11. *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

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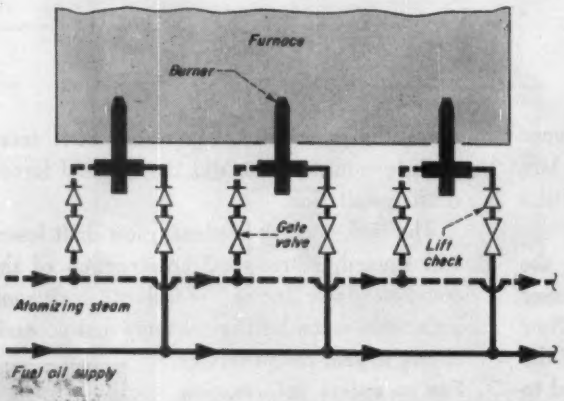
More PRACTICAL IDEAS

Begins on page 138

Reduce scrap loss by showing cost to employees

Scrap loss has been cut to the bone in our plant by a simple graphic display, photo. Display has panels on which we mounted 2 square-foot or linear-foot specimen of sheet, plate, bar stock and angle iron. Cost is marked on each piece, changed periodically to reflect changes in mill prices. Displays are moved around the shop at set periods so everyone can see them. This idea can be used in almost any plant.

F KAISS *Hagerstown, Md.*



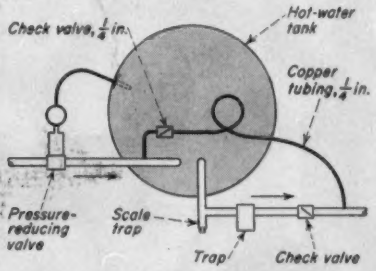
Here's how to keep oil out of your condensate system

In POWER, Aug 1956, p 113, H M Neuhaus tells how he prevented oil contamination of a condensate system. With steam-atomizing burners, recommended design has check valves in steam and oil lines between the supply headers and burners. My sketch is an elementary diagram of this arrangement. Preference is for lift-check valves which seat easier than swing-check valves, especially for small sizes.

With this hookup, reduction of steam pressure allows check valve to close. This prevents reverse flow of fuel oil due to partial vacuum caused by condensed steam.

Better check your fuel-oil system and make sure it is properly hooked up. Oil contamination is costly.

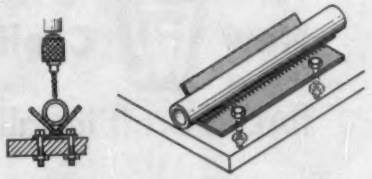
H B WAYNE *Brooklyn, N. Y.*



Stop water hammer

My sketch shows our cure for hammering between the pressure-reducing valve and tank in a hot-water tank. We welded a ¼-in. nipple to incoming steam line, installed a ¼-in. check valve, then ran a ¼-in. tubing to low side of trap. If your system has a check valve after the trap, connect your copper tubing downstream as shown. This hookup breaks the vacuum in the tank's tube coil or bundle. It stopped five tanks from hammering for us.

M B WIDENHOUSE *Patton, Calif.*



Jig for drilling round stock

Handy gadget around shop for drilling holes in round stock, pipe, etc, is made of angle iron. Weld a flat base to angle iron, then bolt or clamp to drill press as shown. This rig holds pipe securely without letting it turn.

L E POLIKOFF *Brooklyn, N. Y.*

Do you know . . .

how to groove a vertical bearing? A heavy-duty horizontal bearing? A thrust bearing? Bearing with thrust on upper half? These and many other jobs are clearly explained with more than 1500 illustrations in *Plant Operators' Manual*, McGraw-Hill Book Co.

My biggest boner

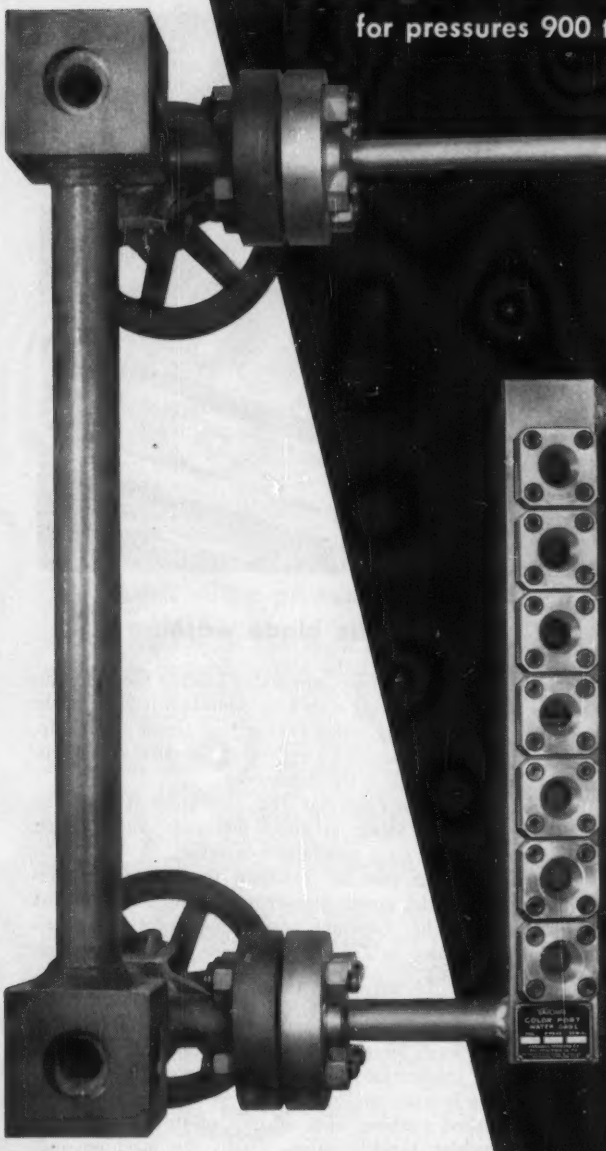
Please turn to page 212

NEW FROM YARWAY!

COLOR-PORT

BOILER WATER LEVEL GAGE

for pressures 900 to 3000 psi

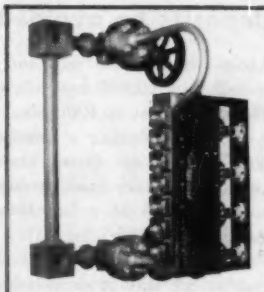


- *two-color readings!*
- *reduced maintenance!*
- *increased availability!*

Now Yarway offers brilliant two-color boiler water level readings, combined with simplicity of gage maintenance and increased availability.

With the new Yarway Color-Port Gage, water space shows green, steam space shows red. A full gage is all green and an empty gage all red.

The Color-Port Gage is *serviced quickly in place* by simple replacement of individual cover-glass assemblies. Each cover assembly is held solidly in place by four socket head capscrews and the "floating assembly" design applies safe predetermined loads on glass ports, reducing thermal shocks, and permitting faster warm-up. *Increased availability means longer service life.*



Side view of Yarway Color-Port Water Level Gage with illuminator, circulating tie-bar and Welbond gage valves.

Write today for new Bulletin WG-1814, completely describing Yarway Color-Port High Pressure Water Level Gages.

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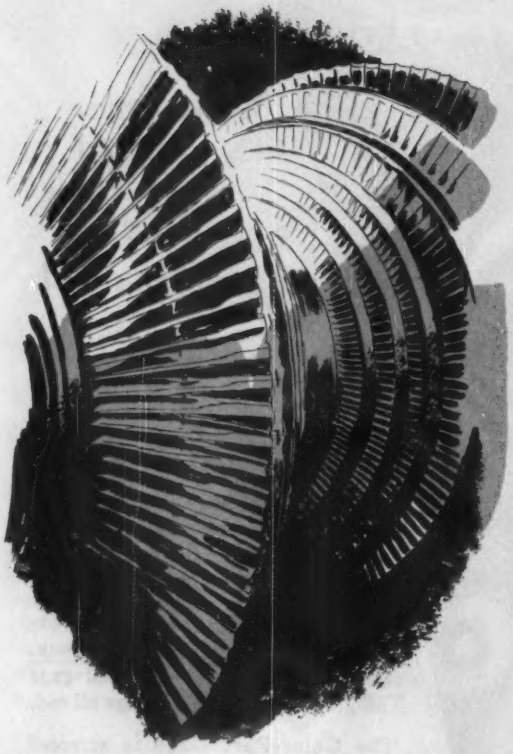
100 Mermaid Avenue, Philadelphia 18, Penna.

BRANCH OFFICES IN PRINCIPAL CITIES.

YARWAY® WATER LEVEL GAGES

Have a PLANT PROBLEM? *Tap the*



The question

How can turbine-blade deposits be avoided?

About three years ago our municipal power plant installed a 10,000-kw condensing turbine-generator. Throttle steam is 400 psig, 750 F.

Recently, during a scheduled removal of the turbine casing, we found scale deposits on the high- and low-pressure blading stages. Our feedwater treatment consists of a hot lime-soda softener that was installed in 1936.

Since we have a relatively-low-makeup feedwater system, we find it economical to use city water.

While turbine-blade deposits weren't extensive, we don't want the condition to get worse. But we don't want to foot the bill for an entirely new water-treatment system, if we can possibly help it. Have readers suggestions to offer?—*SCS, Sept Power*

The answers

Try periodic blade washing

If the deposits, photo above, are water soluble they may be washed off turbine blading with a condensate-injection nozzle installed in the 400-psig steam header just ahead of the turbine throttle valve. Connect a recording temperature instrument to the thermowell in the steam inlet.

Unload the turbine-generator and disconnect it from the bus. With turbine idling at about 500 rpm, and exhaust cut to atmosphere, start condensate injection.

Control injection rate by watching the temperature recorder and let inlet steam temperature drop at a rate of about 100 F per hr. Continue until temperature at the turbine inlet decreases to 275 F and turbine exhaust temperature drops to 225 F.

When these temperatures are reached, increase condensate injection until a small stream comes from the turbine outlet. Continue this wash for about an hour. Measuring dissolved solids in the condensate stream at the turbine outlet tells when washing is complete.

When finished washing, shut off condensate injection and close the turbine throttle valve. Drain the machine and, following the usual cold-start procedure, put the turbine back on the line.

We use this method with good results. However, *SCS* should check with the turbine manufacturer for specific washing instructions.

It might well be that the silica deposits are the result of poor boiler operation. If silica carryover in steam from boiler is low, problem will solve itself.

A E Pritchard, *Jennings, Mo.*

know-how of over 45,000 Power readers

HOWARD KALLEN, *Associate Editor*

More than just a turbine problem

SCS says "We find it economical to use city water." If this means that he's not even using internal feedwater treatment, he's lucky to have his boilers last so long.

Blade scale removal is a tricky procedure, usually consisting of running the machine unloaded and introducing water at the throttle. However, this sounds more like a symptom of serious trouble in the boiler than just a turbine problem. If he also has trouble getting his boiler to produce the rated superheat temperature at rated loads, I'd suspect scale build up in the superheater, too. Sudden temperature drops on load increases would be another indication of carryover.

With his boilers, he might do all right with his present softener plus internal treatment. If he's working with a limited budget, his best bet would be to take feedwater and scale samples to a good chemist. Analysis will show up the troublesome ions and from there his operators can learn to run the prescribed daily tests and make corrections.

H HOLCOMBE, *Los Alamos, New Mexico*

Check silica pickup in feedwater

Deposits found by *SCS* on the high-pressure stage blading are soluble, probably sodium silicate. Washing the blading during reduced operation, by lowering inlet steam temperature to produce wet steam, will remove the deposits.

A temporary desuperheater in the steam line gives control in reducing inlet steam temperature. Similar steam conditions exist during low-load operation of the turbine and boiler, especially just prior to shutdown. During the wash operation, hotwell condensate should be analyzed often to determine peak removal period, as well as the character of the removed deposits.

However, *SCS* will find that most of the low-pressure blading deposit is insoluble. Generally, the turbine has to be opened and some abrasive action, such as flyash blasting used to remove these deposits. his procedure is costly both from manpower and capacity loss angles.

Laboratory tests show that at pressures around 400 psi, silica discharges from the boiler as a vapor with the steam. Decreasing steam pressure through the turbine means silica vapor crystallizes and remains as a deposit on the lower pressure blading and buckets.

SCS can remove this silica from the water in his present hot lime-soda softeners. Depending upon the present water condition, add magnesium oxide, in the right amount, to the treating cycle, then recirculate part of the magnesium-bearing sludge to the top of the softener tank. Magnesium oxide is effective for silica removal, and it doesn't increase feedwater's total solids.

Internal treatment isn't recommended for silica removal because close control of phosphate residuals and alkalinity is necessary, but difficult to maintain in the boiler. Preferred is external treatment, using magnesium oxide.

SCS should also check the feedwater route and eliminate sources of silica pickup, such as concrete storage tanks and sand filters. City water should be treated since it isn't suitable for direct use in the boilers.

Another source of silica are asbestos-type gaskets in the feedwater and steam piping. If *SCS* has these, he should replace them with monel or stainless. The search for silica should include inspection of traps in piping, boiler steam drums and lower waterwall headers.

A J BREUCELMANS, *New York, N. Y.*

Use chemical control program

Several factors have to be considered in connection with *SCS's* problem. Taking for granted that he's using proper chemical control of feedwater, the deposits may result from impurities existing in the system when the units were first started. This was our experience with two 7500-kw machines. When we first inspected them we found light deposits on nozzles and blading in the low-pressure stages. They were easily removed, but their nature indicated they were caused by improper clean-out of the system prior to startup.

SCS doesn't mention what type of chemical control he's using on his boilers. Chemical control is an important factor in producing good quality steam for the turbine. Dissolved solids should be held under 1500 ppm on a 400-psig unit. Silica, if present in water, should be held under 50 ppm.

If he is using good chemical control, maybe he's carrying his boiler-water level too high. This can cause carryover, especially at high steaming rates. Carryover, of course, always causes blade deposits.

Is all return condensate free from oil contamination? If not, he'll get foaming. *Result:* Poor quality steam. It's no secret that poor quality steam can mean blade deposits.

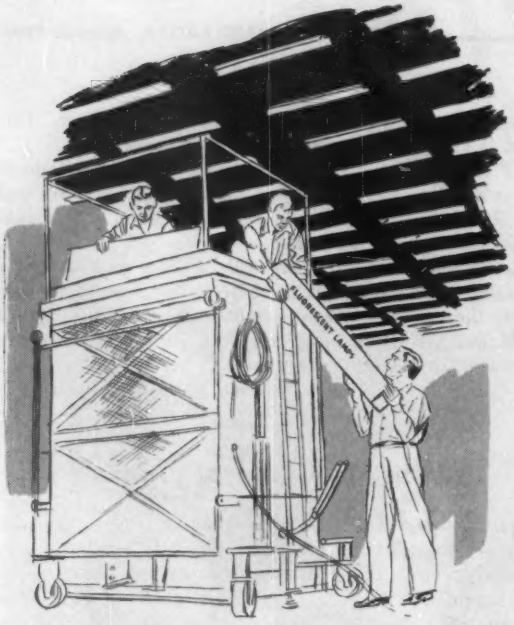
His hot lime-soda unit needs regular checking to insure good quality effluent. Many plants use this process successfully, but they also tie in a topnotch chemical control program. Such a program for medium pressure plants doesn't cost a lot of money. We generate over 10,000,000 kw per month with two 600-psig units with a boiler chemical cost of about $35 per month. Our operators do all the water testing and the men vie with each other to maintain the best chemical control possible. We get top results.

J A FULLER, *Oro Grande, Calif.*

Want help with your plant problems? Send in your design and operating headaches to us. We'll give Power readers a whack at them.

Turn page for info on group lighting replacement

More PLANT PROBLEMS Begins on page 144



The question

Should we use group replacement for our fluorescent lamps?

Our metals-fabricating plant is housed in a 5-floor building that uses almost 1000 fluorescent fixtures. These are 4-lamp units.

Up to now, we've been replacing these units when they burn out, rather than scheduling them on a regular basis.

Some plant engineers in our area are apparently sold on the group replacement system. But I'm not convinced it can actually save us money. Also, several different replacement schemes are being used. One plan is based on the number of lamp failures in a given area. Another replaces all lamps when they reach 80% of their expected life.

Are readers using these methods in their plants? How are they working out?—*IAR, Sept Power*

The answers

Middle-of-the-road approach: Replace all burnouts at scheduled intervals

Group replacement often pays off in high-bay areas which can tolerate a 20% lighting loss. Spot replacement is expensive. So *IAR's* best bet might well fall somewhere between group and spot replacement—let's call it scheduled spot replacement. Use a light meter to help determine proper time interval between changes. Then set up schedules based on elapsed time. This setup should suit his needs.

H HOLCOMBE, *Los Alamos, N. M.*

Fork trucks speed lamp maintenance

IAR must remember that lamp life is affected by number of starts and stops. Might be that by leaving some lights burning he would cut down on replacements.

In our case the maintenance staff is small so we feel group replacement is not for us. We make spot replacements on a regular schedule. While we're at it the fixture is cleaned. A fork truck with working platform is used on all overhead lamp work, saving us considerable time and effort.

L E POLIKOFF, *Brooklyn, N. Y.*

Hold 25% of lamps for trouble calls

Group replace by all means, but hang onto 25% of the best lamps removed. Following the 80%-life plan means group replacement is called for when about 800 lamps of the original 4000 have failed. Keep about 800 of the remaining 3200 lamps for interim replacement.

A J BREUGELMANS, *New York, N. Y.*

Outside lighting maintenance contractor?

IAR might consider group replacement on a maintenance contract basis. Then all reflectors are cleaned periodically while a check is made on ballasts, wiring, starters. He then will be getting top light output without interfering with production workers. Also, plant maintenance men will have more time for jobs more pressing than lamp maintenance.

W F MYLES, *Montreal, Canada*

Look at the overall cost, then decide

Group replacement is particularly economical where lamps are spread over many floors, covering wide areas. And if *IAR* does switch to group replacement, he might try doing the work on the night shift when a skeleton production crew is working. He'll keep interruptions to a minimum.

H B WAYNE, *Brooklyn, N. Y.*

For more on group lighting replacement and new problems, turn page

A Small Plant Modernizes with DETROIT STOKER

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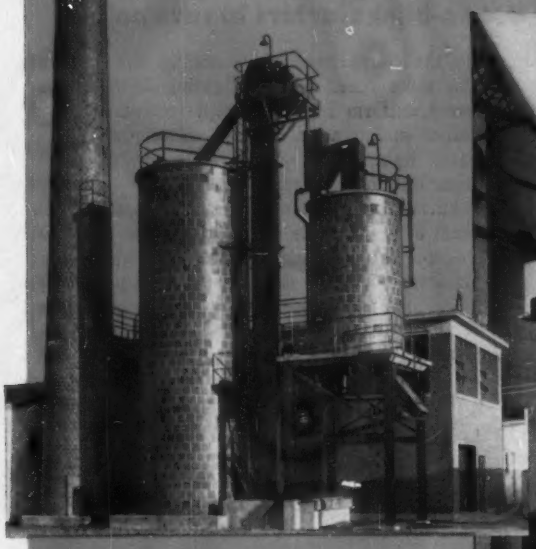

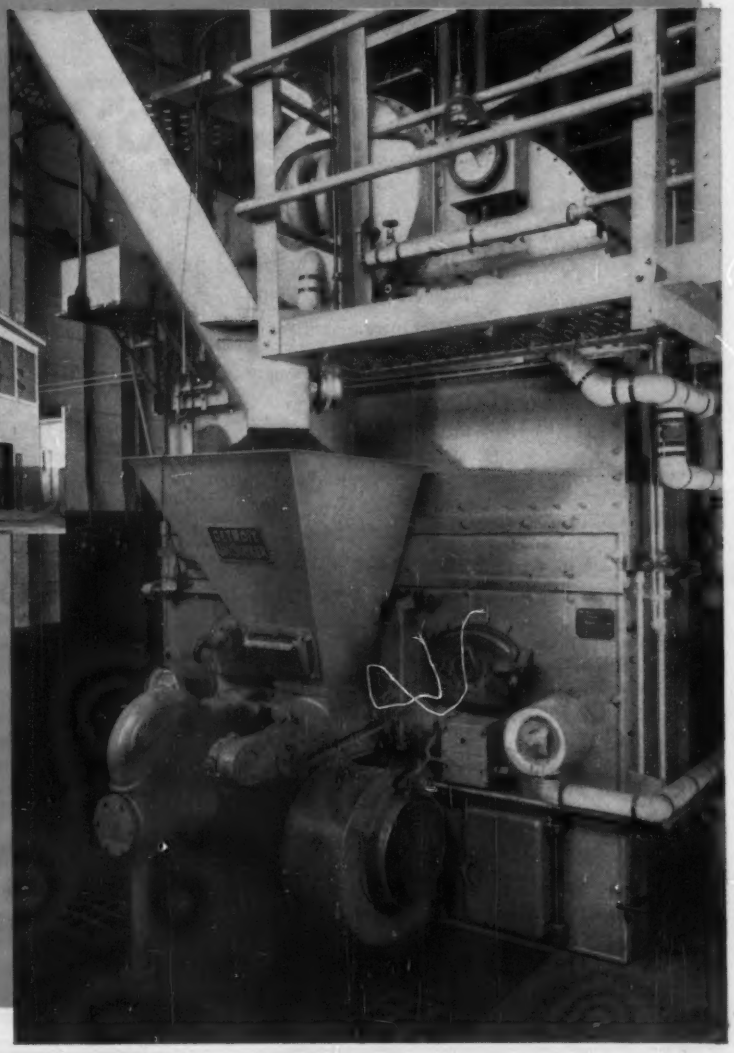

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More PLANT PROBLEMS Begins on page 144

Here's how to figure charge per unit time

To arbitrarily say a group replacement schedule, based on 80% of lamp life expectancy is more economical than spot replacement, is based on whim rather than logical analysis. Best approach is to determine the total cost per hour by adding cost of lamps and labor charges per unit time. Here's a set of formulas that yield reliable answers:

$$A_1 = \frac{N\,(C + t_1\,W)}{PL}$$

$$A_2 = \frac{N\,(C + t_2\,W)}{L}$$

A_1 = Cost of tubes based on group replacement ($ per hr)
A_2 = Cost of tubes based on unit replacement ($ per hr)
N = Number of tubes
P = Fraction of life expectancy for every replacement
L = Life expectancy (hrs)
C = Cost per tube ($)
t_1 = Time to replace one tube when entire bank is replaced
t_2 = Time required to replace a single tube at a time
W = Labor cost for replacement ($ per hr)

If we equate A_1 and A_2, we may find the value of P for which the two methods yield the same cost, thus:

$$P = \frac{C + t_1\,W}{C + t_2\,W}$$

A Di Lorenzo, *Brooklyn, N. Y.*

Spot replacement is used in this 5000 lamp plant

We have 2500 40-watt 2-lamp fixtures. Two lamp men, following a spot-replacement scheme, handle the job.

Obeno Cuoghi, *New York, N. Y.*

Set up a record system first—then decide

Keeping track of lamp service in different plant sections is *IAR's* first chore. He might divide plant into four sections and experiment with variations of group replacement and straight burnout replacement. After studying his records the best course to follow will become quite evident.

C G Howarter, *Canton, Ill.*

Drain oil on time basis . . . why not lamps?

Some plants drain oil on a time rather than running basis. This makes sense, so why not do the same for fluorescent lighting. And if *IAR* goes to group replacement I suggest he keep a careful set of records. They'll prove handy later.

S A Frank, *Newport, N. H.*

Use no-blink starters to save calls

In addition to the convenience of relamping and cleaning fixtures at the same time, average lighting level will be higher and more uniform for group replacement. *Reason:* Fluorescent tubes maintain an average of somewhat near 80% their rated light output during expected life span. Beyond this point light output drops fast.

Added thought: when maintenance men are washing fixtures, have them add anti-static compound to the water for reducing the dust-attractive static charge. Also, when going to group replacement consider use of no-blink type starters to avoid long periods of attempted starts before replacement time. If *IAR* is running into unusually short lamp life, I suggest he check line voltage, and ballasts.

W H Keith, *Albany, Ga.*

Your December Problems

1 Should controllers be reverse or direct acting?

Our food-processing plant is planning to add several steam-heated process heaters. Arrangement calls for a temperature controller sensing temperature of the liquid leaving each heater. Flow controller measures steam flow to the heater and also receives an air signal from the temperature controller. Air signal from the flow controller then actuates a control valve in the heater's inlet steam line.

Desired result is to have a constant liquid outlet temperature by controlling steam flow to the heater. I'd like to know whether we need reverse- or direct-acting temperature controllers; reverse- or direct-acting flow controllers?—*PDO*

2 How can we supply water to fire-fighting system at all times?

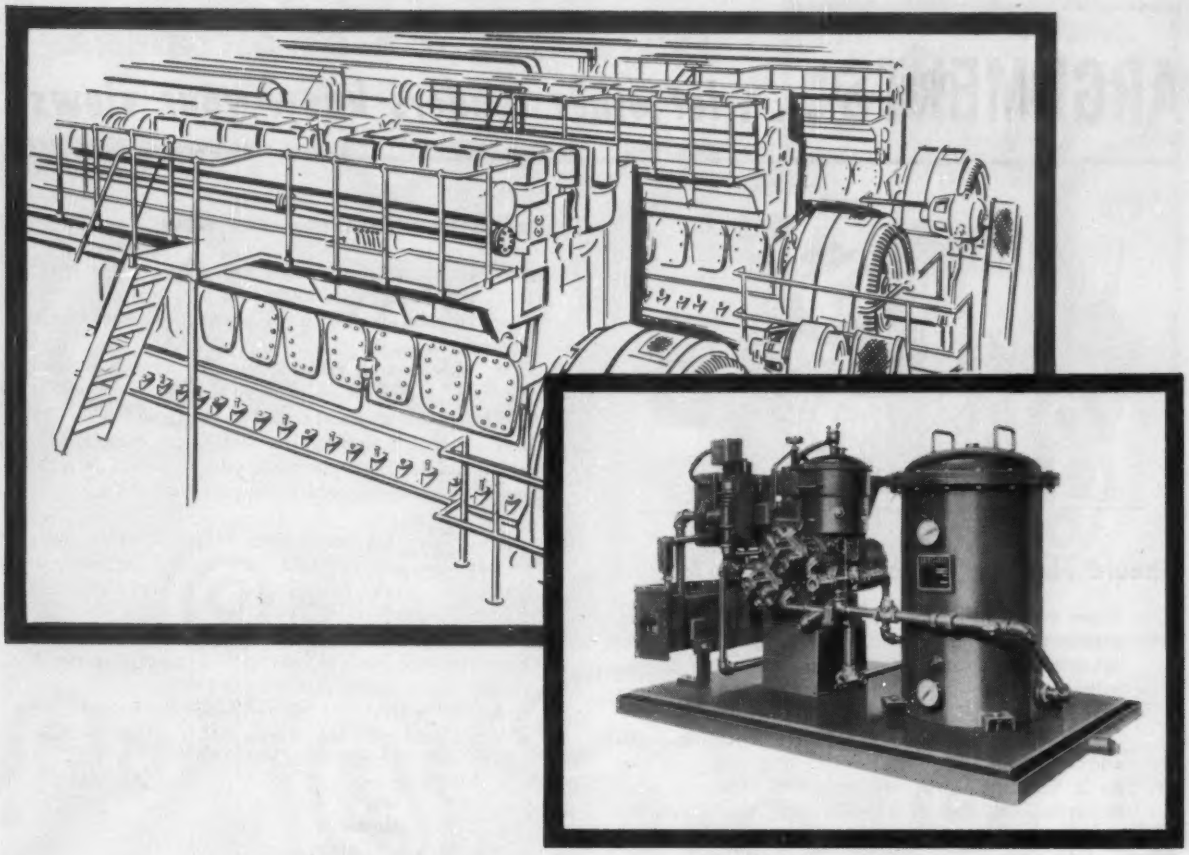
I'm engineer for a small hospital that's located close to a beach. We must use a salt-water supplied fire-fighting system because the village supply is inadequate and unreliable.

How can we have a reliable supply with a pump that must draw about 24 ft from extreme low tide? How can we avoid fouling with marine growths?

Our area is regularly hit with severe winter storms, ruling out a wharf. The beach is about 100 ft long and, except for a thin layer of gravel, it's solid rock.

The pump and motor installation is no problem. But we need some form of permanent suction arrangement that's relatively troublefree—*DT*

Sit down right now and answer one or both problems. We'll pay extra for answers with photos or sketches.



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ARGUMENTS . . . *let other readers know your views*

ALTHEA THORNTON, *Assistant Editor*

Should engineer be consultant too?

Three of us, all engineers, are employed full time by a large firm as specialists in three separate fields. Because we are approached from time to time to do consulting work on the side, we want to form a consulting firm and go after business in our spare time.

I know several top engineers in leading firms who add substantially to their income this way, and they do it with their firm's blessing. Management takes the attitude that every job these engineers do on the outside adds to the company's prestige for employing such top-level men.

We three want to form a partnership and go after business openly. This isn't possible now because several high executives frown on us doing outside work while on the company's payroll. It just happens that our specialties are rather exclusive and therefore in demand. Could POWER readers, both top-level management employing engineers and consultants, send in their views?

THREE AMBITIOUS ENGINEERS *New York, N. Y.*

Marmy is rusty on safety

Being a member of our plant's safety committee, I can see that Marmy is a little rusty when it comes to safety. Take July POWER for instance. He's looking through a boiler peephole without using a shield to protect his eyes and face from the fire. And the man standing at his back surely isn't helping any. Didn't safety training exist many years ago?

D I CALLEJA *Key West, Fla.*

EDITOR'S NOTE: *Marmy is so horny-handed and weather-beaten that a little thing like looking directly at a 2732-F fire hardly warms his eyebrows. But that doesn't mean any ordinary engineer should try it.*

Oil immersion extends usefulness

I refer to the electrostatic instruments mentioned in POWER, Nov 1956, p 131. Immersing in oil or enclosing in a gas-filled chamber under pressure extends use of these instruments to voltages over 100 kv. Damping effect of oil permits much closer readings. This is particularly valuable since no energy is used.

C O VON DANNENBERG *Brooklyn, N. Y.*

Taylor asks about reverse flow

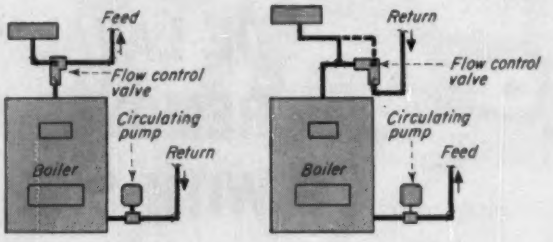
Some things in "Reverse flow to keep air out of radiators," p 119, August POWER, are not clear. I have a lot of trouble with air in my hot-water heating system at home.

My flow-control valve is not the type described, however, as there is no place for electrical connection and it appears to be operated by pump pressure. Apparently it is a check valve. If I reversed the flow, it would not let the water pass unless opened fully by hand. Then there would be no point in having a valve on the system.

Also, since hot water rises and cold water sinks, wouldn't the relatively colder water enter the radiators first? Isn't reverse flow against the natural circulation of heated water?

Another problem is operation of the burner controls. After the high limit has stopped the burner, a return of cold water, under somewhat intermittent operation, causes the control to work as though the boiler water were all cold. Burner starts, and will not cut out. What would reverse flow do about this?

A E TAYLOR *Uxbridge, Mass.*



CONVENTIONAL HOOKUP REVERSE FLOW

Jahne answers Taylor's questions

Sketches, above, may help iron out Reader Taylor's problems. On conventional system, left, the flow-control-valve flapper is connected to the boiler through the pipe nipple. System may be vented as shown, or otherwise. Trapped air is a frequent problem.

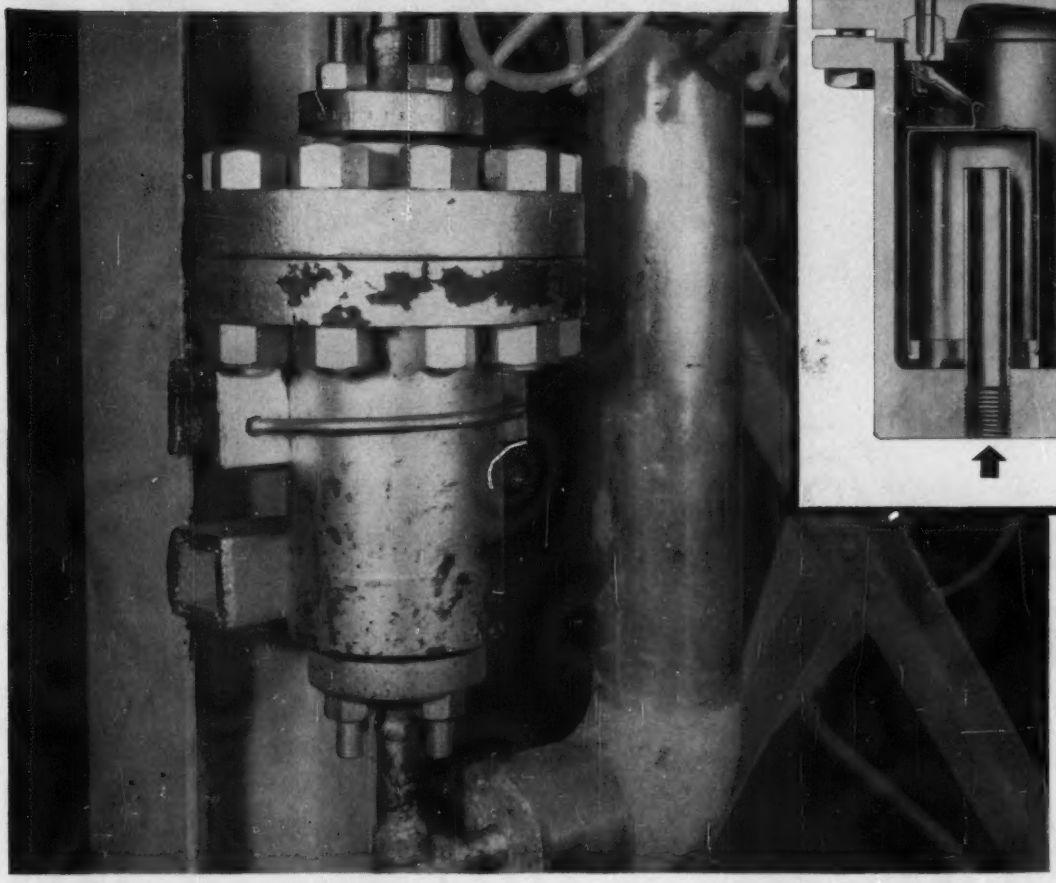
In the reverse flow installation, right, the valve has been turned some 180 deg in both vertical and horizontal planes. Return line is trapped, and water opens valve flapper when circulating pump starts. System is vented on boiler side of the valve flapper. Dotted lines show an alternate venting method.

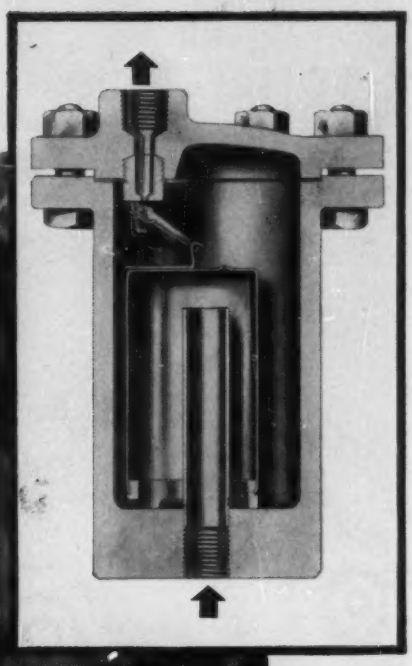
As Taylor says, water in the bottom, laying dormant, may be cooler. But once circulating pump starts, water becomes turbulent and temperature throughout the boiler becomes almost even. This turbulent water is what enters the radiators.

So a system designed for 180 F may actually feed at 175 or 178 F. It is true that cooler water enters top of boiler from the return line. But this water mixes and is heated almost immediately. Burner should then shut off.

CHARLES JAHNE *Baltimore, Md.*

ARMSTRONG FORGED STEEL STEAM TRAPS . . .





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Part	Material
CAP AND BODY FORGINGS	
Up to 600 psi, 750°	1030 carbon steel
Up to 900 psi, 900°	ASTM Spec. F-1 carbon moly steel
Up to 2500 psi, above 900°	ASTM Spec. F-5 chrome moly steel
VALVE AND SEAT	Type 440 chrome steel, heat treated, standard. Stellite available.
LEVER MECHANISM	Stainless steel
BUCKET	Stainless steel
BOLTS	Class C high tensile, high temperature bolting material—125,000 min. tensile.
NUTS	Hex, semi-finish, heat treated for high pressure, high temperature service.
GASKET	Compressed graphited asbestos
INLET TUBE	Wrought iron

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SEND FOR THIS LITERATURE:

1. **Should we trap superheated steam lines?**—the answers of 11 engineers who have used traps for this service.

2. **Catalog J**—complete data on forged steel traps and steam trapping.

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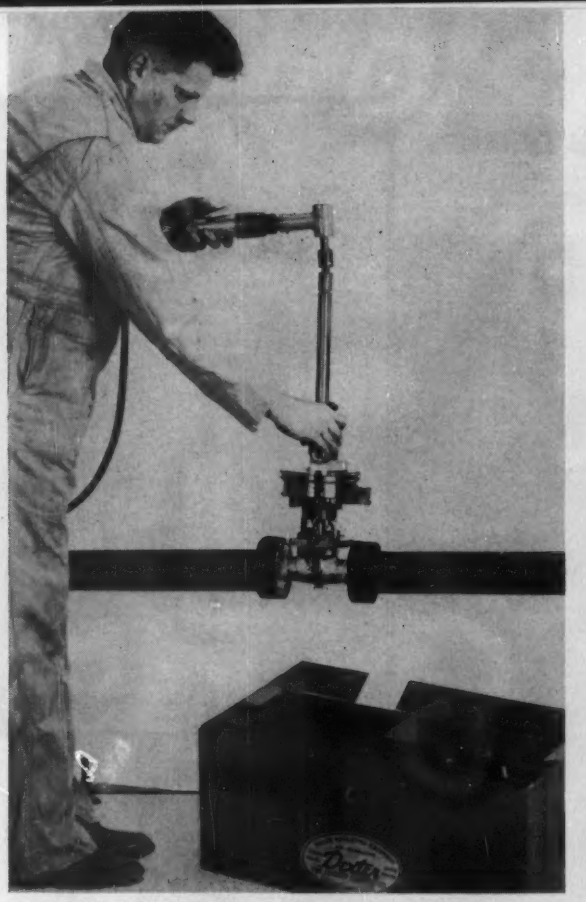
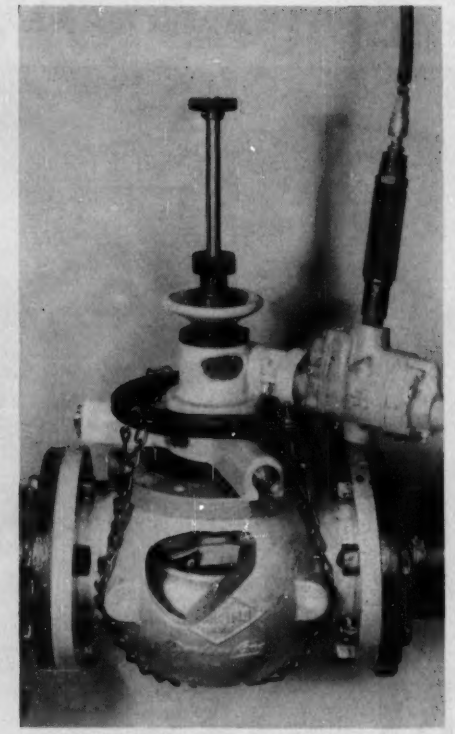


RESEATING GRINDER is motor-driven, can be set up on gate or globe valve without removing the valve body from the line



ANOTHER TYPE rig is for large globe valves: can also be used inverted for overhead valves

HOW TO

reseat valves in the line

► PLANT MAINTENANCE ENGINEERS face the problem of valves failing due to leaking valve seats. Removing valves to recondition them in maintenance shops is costly, especially with today's high labor cost. And regrinding in line with makeshift hand methods has its drawbacks.

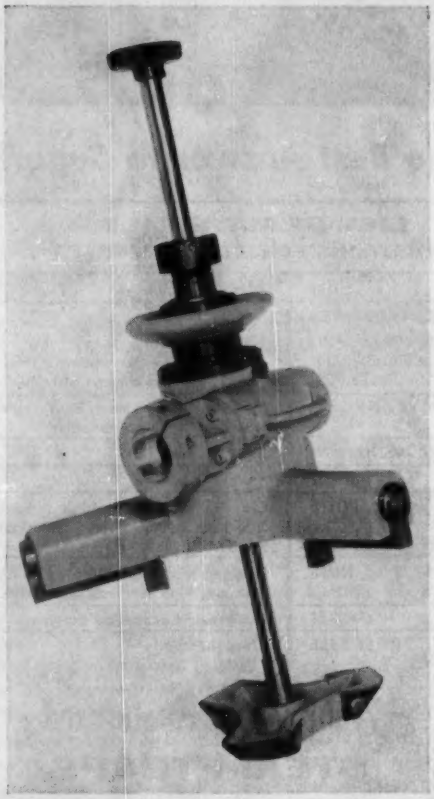
Now you can do this job with the valve-reseating grinder shown. It grinds the seat of any globe or gate valve in the line, regardless of valve materials' hardness.

This precision-built machine does an accurate job by resurfacing irregular valve seats from the same reference point used in machining the original seat.

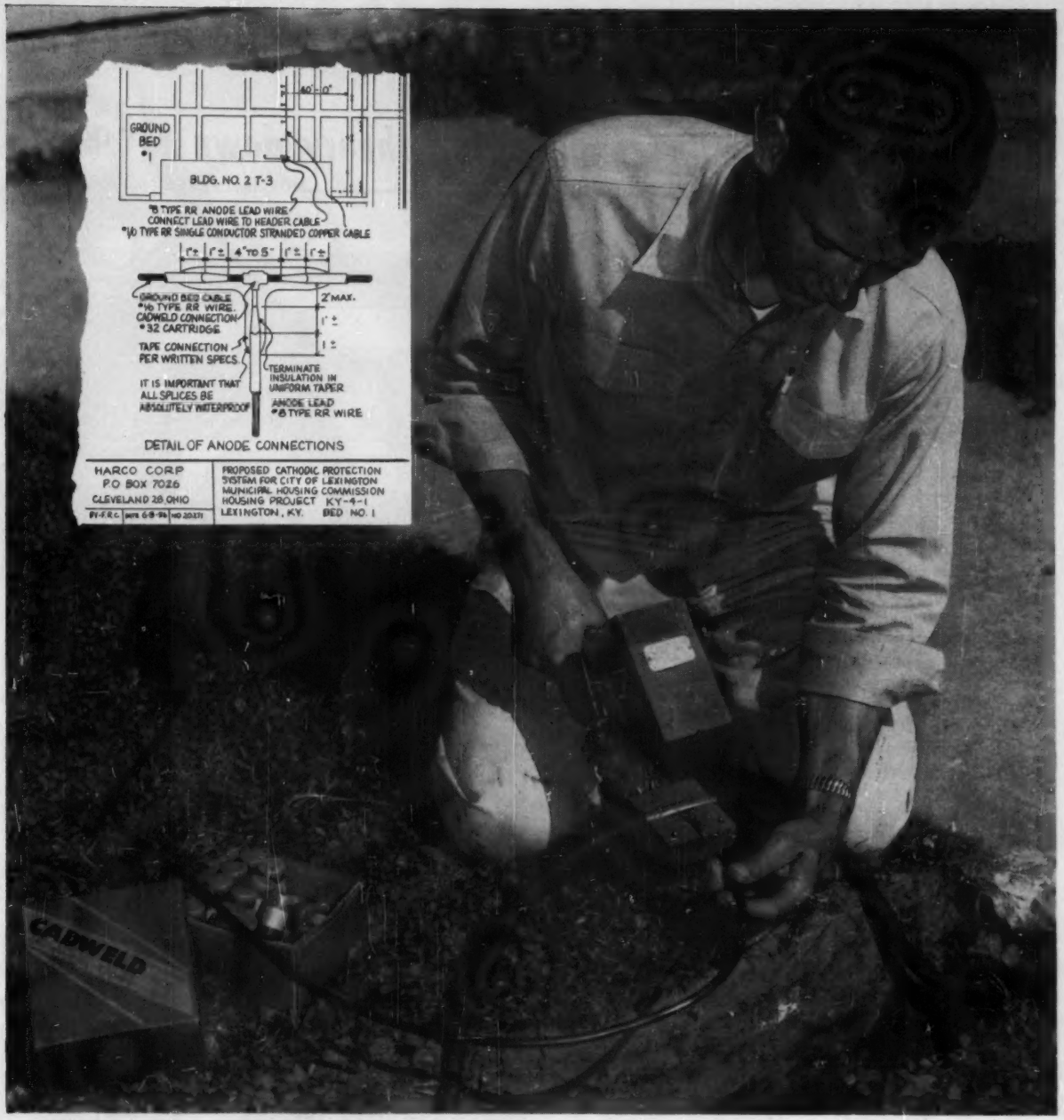
Machine uses abrasive cloth. Grinding elements are made in form of cones or segments and are set on rubber-coated grinding heads to prolong life of the abrasive.

Globe-type valve reseating equipment is positioned on valve bonnet with a universal chuck. Grinding heads are power driven through spindles mounted on radial and thrust bearings. Positive feed on machine feeds grinding head against valve seat. Special adapters are made for small throated or non-removable bonnet bolt-type valves.

—Courtesy, The Leavitt Machine Co, Orange, Mass.



GRINDING DISK on driven spindle is rubber coated to prolong the life of the abrasive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BASICS . . . *bringing engineering theory down to earth*

NORMAN PEACH, *Assistant Editor*

Electricity: 5

Series and parallel circuits

► SIMPLEST CIRCUIT you'll encounter is a series circuit with only one element in it that has a significant amount of resistance. But other parts of this circuit, like the wires and power source (battery or generator), have some resistance. Total resistance of series circuit is sum of resistances of parts. Formula is: $R = r_1 + r_2 + r_3 \ldots$

Current is the same in all parts of the circuit. Voltage drop (IR) across each element in circuit is proportional to resistance of the element. This is sometimes important from insulation standpoint. *Example:* In a field coil with a thousand turns or more, voltage across the insulation between adjacent turns is possibly only a fraction of a volt, but full line voltage is between the first and last turns. (In certain circumstances voltage across field can go much higher than line voltage due to inductive effects of coils.) Be very careful to insulate lead turns adequately. Power loss (I^2R) is also proportional to resistance since current is the same throughout circuit.

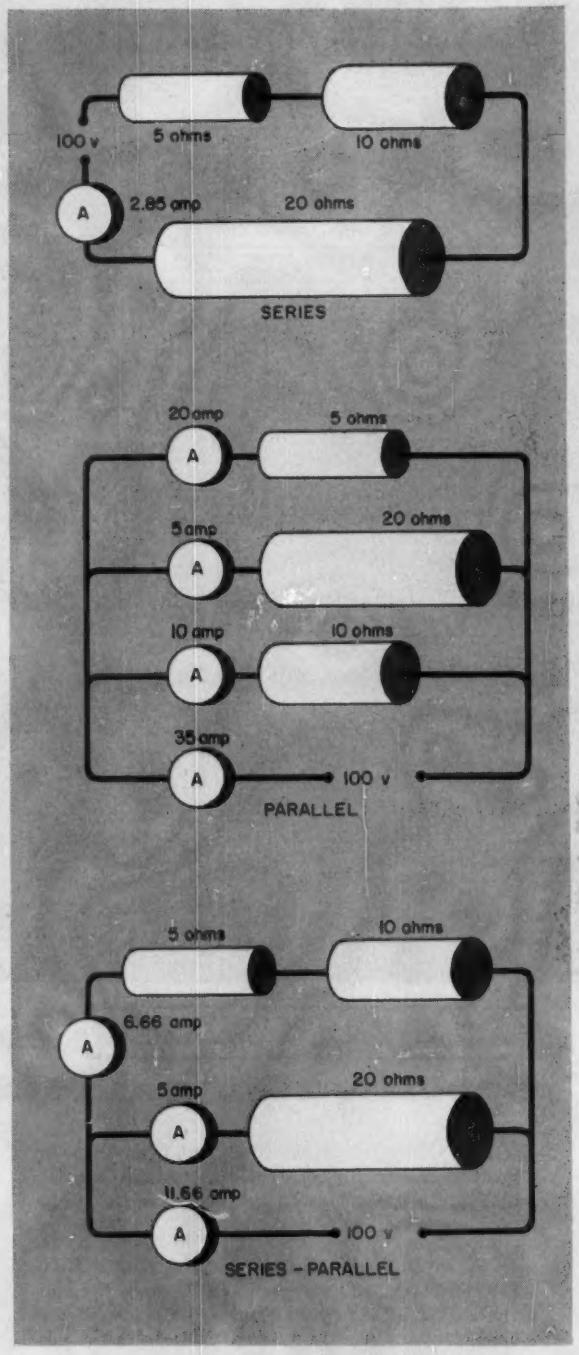
In parallel circuits full voltage is across each element and current in each element is inversely proportional to its resistance. Total current taken by the circuit is sum of the currents in each element. Total resistance of parallel circuits can be found by the formula:

$$R = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \frac{1}{r_4} \ldots .}$$

When finding resistance of parallel circuits it's probably easier to think in terms of *conductance*. Conductance is the ability of a circuit element to conduct electricity; it's the reciprocal of resistance, or $\frac{1}{R}$. Units of conductance are called *mhos*. Thus 5 ohms equals $\frac{1}{5}$ mho. Convert resistance of each element to conductance and add to get total conductance in mhos. Take reciprocal of total conductance $\frac{1}{G}$ to get resistance. Considering circuit in sketch, we have 0.2 mho + 0.1 mho + 0.05 mho = 0.35 mho. Taking reciprocal of 0.35 mho we get 2.75 ohms. If all elements in a parallel circuit have the same resistance it's easy to find total resistance; just divide resistance of one element by number of elements in parallel.

Actual circuits are usually combinations of series and parallel circuits. In simple series-parallel circuits, figure series circuits first, then consider them as elements in parallel circuits. Series-parallel circuits can be very complicated, however. Even the distribution system in a large plant can require special mathematical techniques to analyze current, voltage and resistance relationships. (Since these circuits are nearly always ac, other factors add complexity.)

Next month's Basics: *Electrolytic circuits.*



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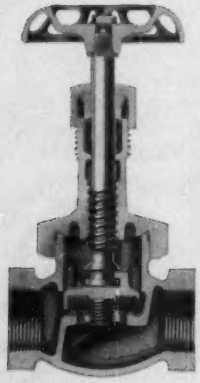

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"That evening the food-processing plants' super came aboard and handed me a check for $900," roared Marmy

Marmy breezes through

► TODAY'S SLICK steam-turbine plants with their oil-, gas- or stoker-fired boilers are a far cry from the old steam-engine plants, powered by hand-fired coal-burning boilers. And today's push-button operators who run these modern plants are a different breed of cats from those two-fisted engineers of yesteryear. But to keep in touch with the good old days, I need only to walk a few blocks down the street to O'Houlihan's Machine Shop and Engine Works. At the top of the creaky oil-soaked wooden steps leading to the second floor is a bright-red door. Painted over the glazed glass is the impossible name of Marmaduke Surfaceblow, Consulting Engineer.

Fed up with all this modern stuff about atomic reactors, fluidized combustion, automation and what have you, I got homesick for the old slice-bar days and headed for Marmy's office.

As I opened the door I was greeted by a blast of acrid eye-stinging tobacco smoke. Through that No. 5 Ringelman smog I could make out Marmy sitting at his swivel chair. Holding down the ship's settee along the side wall were his burly shipmates and hangers-on. I didn't have to see them, I could hear them. Mixed in with loud gravelly guffaws and slurps from coffee cups I vaguely made out an argument about burning coal. Marmy paid no attention to that hubbub as he scribbled on some old blueprints and puffed furiously on his short cigar butt.

Wiping the tears from my eyes, I stepped inside. "So I rebuilt the furnaces on the old SS *President Adams* and saved 7 tons of coal a day," barked a tough looking character with a blackened right eye.

"BILGEWATER on rebuilding furnaces to save fuel," suddenly roared Marmy in his foghorn voice, throwing down his pencil and propping his size-16 canal boats on his ancient roll-top desk. "I'll tell you slice-bar engineers about the time I solved a tough combustion problem and all I did was make a few telephone calls."

That did it. The chatter stopped. I poured myself a cup of coffee from the kettle atop the pot-bellied stove, then plopped down on a squeaky chair. Marmy leaned back in his swivel chair, yawned, gave his bowler the usual starboard list, then revved up his induced-draft fan and puffed on his rope yarn. Exhausting a cloud to the ceiling, he blasted away full throttle.

"Back in 1946 I pulled into Chicago aboard a grain ship from Duluth. After getting things squared away below, my first assistant and I headed for the Hofbrau Tavern in the Loop. We sat down at a corner table and started stoking our boilers with sauerbraten and steins of lager. Just as we started on our second order, two guys came in and anchored at the next table. I recognized one of them as Hal Godly. He'd passed coal for me on a South African Line freighter years before. We shook hands and he introduced his friend, a local stoker salesman. It turned out that Godly was the plant engineer of a food-processing plant in East Chicago.

"I invited them to sit at our table. In no time Godly was crying the blues about his boilers, so I asked for details. He was very glad to oblige.

"His boilers had 10 ft wide by 13 ft long pinhole-type grate stokers for burning coke breeze. Breeze is coke

(*Continued on page* 203)

MUD DRUM
as opened
after one year
on line
with
THE *Nalco* SYSTEM

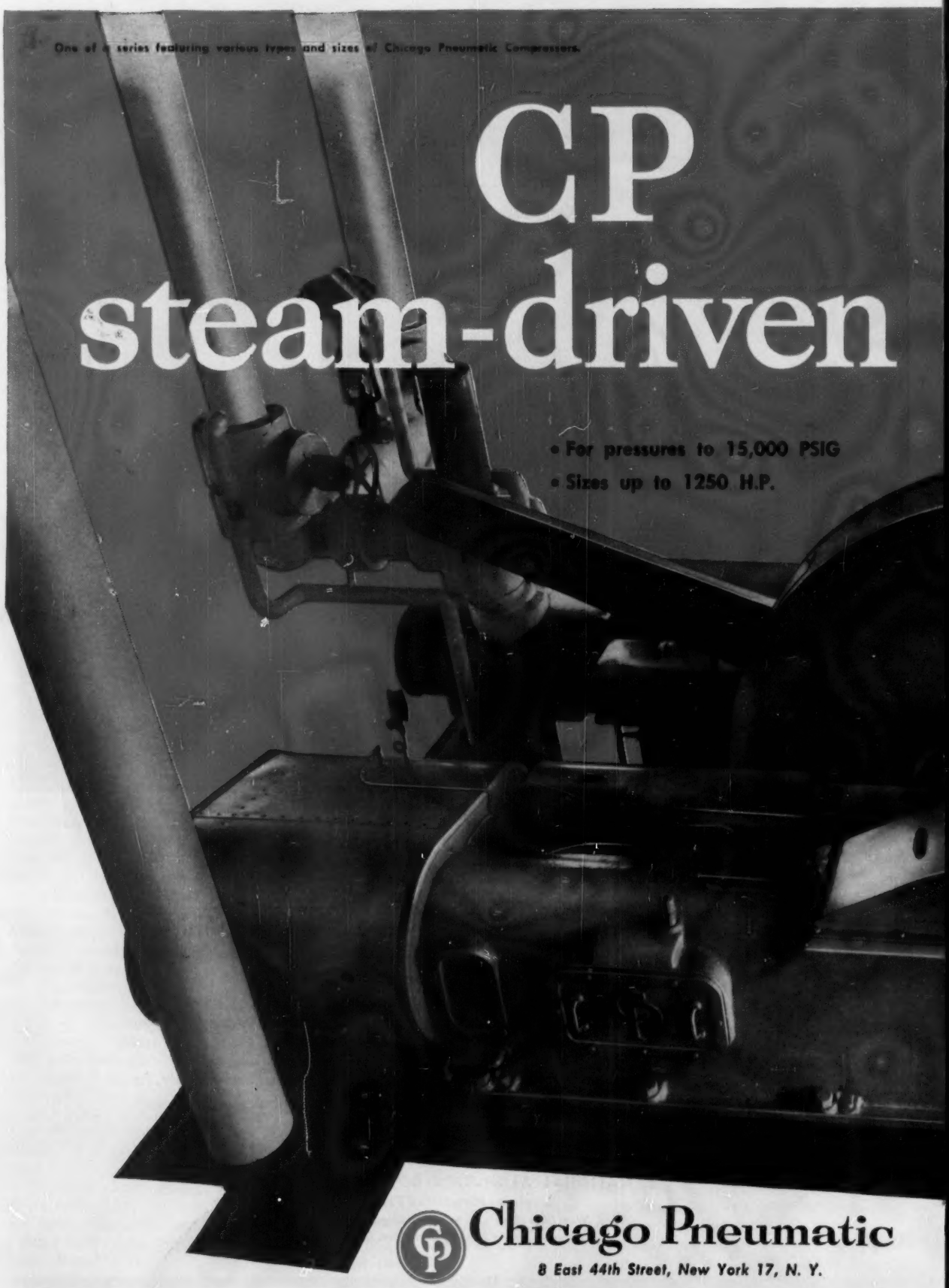
Unretouched photo of Nalco treated boiler at Georgia Institute of Technology, Atlanta, Georgia

● Calling this a mud drum serves only to identify its location . . . it is perfectly clean after a full year on line. The unretouched photo was taken immediately after the drum was opened. No wash-out was necessary. Not only is the drum free of scale and corrosion . . . Nalco sludge conditioning operated so effectively that even under the static, off-line draining condition, no sludge deposited in tubes or drums.

The Nalco System can get results like these, economically, in *your* plant—regardless of boiler size or pressure. Write or phone Nalco today for action on a complete water treatment program.

NATIONAL ALUMINATE CORPORATION
Telephone: POrtsmouth 7-7240
6222 West 66th Place • Chicago 38, Illinois
In Canada: Alchem Limited, Burlington, Ontario

THE *Nalco*® SYSTEM . . . Serving Industry through Practical Applied Science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CP
steam-driven
• For pressures to 15,000 PSIG
• Sizes up to 1250 H.P.

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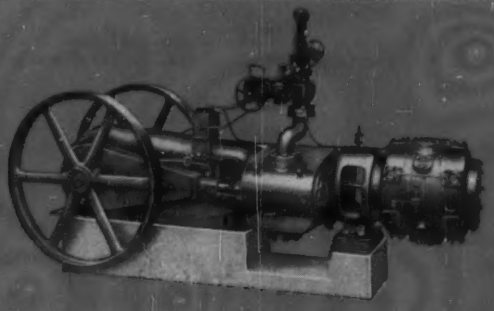


Class T single-stage, horizontal, straight-line, steam-driven compressor. Also available in two- and three-stage designs.

compressors

...for the process industries

Class H, four-corner, steam-driven, single-stage gas booster compressor.

Reader service section

Start with these quick samples...

We told you so...

We say that with pride each time a newspaper headline affirms a story that *Power* readers had first. We realize that, in this fast-moving field, it's important that you know, not only what *is* happening, but what's *going* to happen. For that reason, our reports are keyed to the future. For the stories behind tomorrow's headlines . . .

Reports From the Field, p 162

Headaches ahead...

for users of petroleum lubricants in nuclear power plants? That's the question raised in a recent ASLE paper. Authors outline anticipated problems and suggest a three-step solution. We've digested this and several other papers for your convenience. If, after reading, you want the full report, we tell you how to get it.

Technical Briefs, p 164

Horse and buggy...

equipment can put your plant behind the eight-ball. Perhaps a new regulator is needed—or perhaps efficiency is only a matter of the right meter. Whatever your difficulty, chances are some manufacturer has anticipated it. And chances are we'll be featuring his equipment in our pages. For a handy checklist, use . . .

Plant Equipment News, p 168

Put your 2¢ in...

and receive any one of 40 free bulletins. Subjects covered range from boilers to blowers, meters to maintenance. Take a few minutes now to scan our list and make your choices. Check them off on the postcards we provide, affix a 2-cent stamp and mail.

Free Literature, p 177

Peace and prosperity...

are the goals of all men and the greater of these is peace. For if a man have a full purse and a troubled heart, he cannot account himself rich. Our engineer-philosopher believes that too much emphasis is put on the importance of material gain. So during the Christmas season, he urges us to re-examine our objectives.

George Edwards, p 180

For other timely ideas, see following service pages ▶

Now — A Revolutionary NEW Steam Trap!

INSTALL IT — FORGET IT!

ACTUAL SIZE

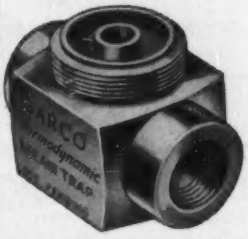
SO RUGGED **SO SIMPLE**

this steam trap practically eliminates maintenance

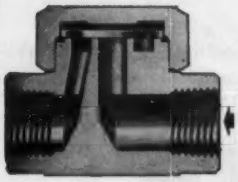
1. A CAP

2. A DISC

3. A BODY



That's all!



SIMPLICITY ITSELF!
No valve-closing mechanisms to wear or stick. No critical clearances to choke. No gaskets to leak. Only moving part a SOLID stainless steel disc.

Major advance in trap design!

Imagine a steam trap machined from a solid block of stainless steel. A trap with only 3 parts...cap, disc and body...and not even a valve-closing mechanism—the kinetic energy of steam closes the valve and ONLY the TD uses this new operating principle.

That's the revolutionary new Sarco type TD. It has only one moving part...a hardened SOLID stainless steel disc. And it is not affected by superheat, water-hammer, corrosive condensate. That's why we can say INSTALL IT—FORGET IT!

Use the SAME trap for 10-600 psi...for light or heavy loads ...without seat or valve change or other adjustments. Closes tight on no load—no steam waste.

Ask for a 60 day trial installation of Sarco TD trap and strainer...write for bulletin 257. Sarco Company, Inc., Empire State Bldg., New York 1, N. Y.

2150-S

SARCO

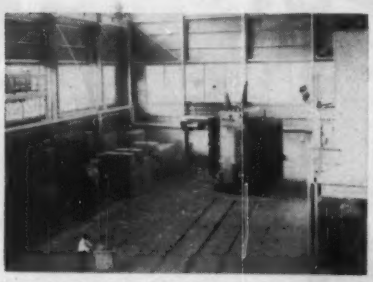
Only Sarco Makes All 5 Types

That's why Sarco can give impartial advice on proper steam trap selection.

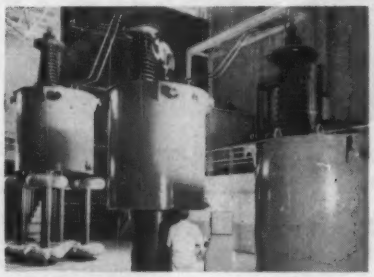
REPORTS FROM THE FIELD

What's happening in power and what it means to you

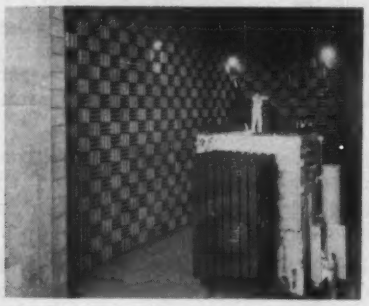
For Calendar of Events see page 224



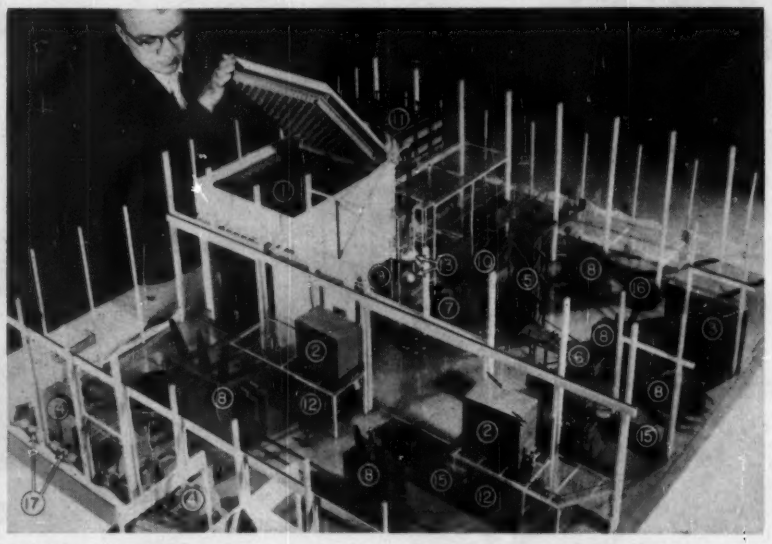
WORLD'S LARGEST TRANSFORMERS will be tested on this Westinghouse test floor



THREE-UNIT cascade transformer bank for development and commercial tests



COMPLETE sound measurements can be made on transformers in anechoic vault



MODEL of Westinghouse $3.5 million high voltage test center. Key numbers on p 222

GE and Westinghouse build for the future

► LIKE THE LEGENDARY "KILROY" of World War II fame, America's big electrical companies pride themselves on being there first. In line with this policy, two of the biggest, General Electric and Westinghouse, have opened research and production testing facilities designed to anticipate the needs of industry by ten or twenty years.

Three years ago, Westinghouse market analysts, foreseeing large-scale production of bigger transformers, recommended expansion of the company's Sharon, Pa. transformer division. Early this November, the $13 million program was completed and the new facility opened for business.

Spokesmen for Westinghouse say that the division's productive capacity for power transformers has been increased by more than 30%. They are confident that, with these improvements, Westinghouse will be able to handle complete commercial tests on units to be built in the next ten years.

Late in Oc- (*Continued on p* 222)

Now—engine output not affected by altitude

► ONE OF THE SADDER FACTS of engineering life is that as altitude increases, engine output decreases. Until recently, engine builders and operators had struggled with this problem without success. Now, however, a solution seems to have been effected.

According to Ralph L Boyer, vice-president of Cooper-Bessemer Corp, internal combustion, 4-cycle engines can now operate at any altitude with no sacrifice in engine output: Two-cycle engines will be capable of operating at 7500 ft without any deration in engine hp.

Supercharging can be made (*Continued on page* 228)

Soviet reveals power plans for Hungary

► A FEW WEEKS prior to the uprisings in Hungary, Soviet sources disclosed an ambitious program for the expansion of power potential in the satellite nations. Just how much of this program will be realized will depend on how badly the Russian applecart has been upset.

Early in September, POWER received a report that a permanent commission had been established by the Soviet with her satellites—under COM-ECON command—to study fullest utilization of Danube waters for run-of-river power plants in Eastern Europe.

The latest Danube Hydro-Power (*Continued on page* 222)

for cooling tower application...

There's MORE protection against humidity in Allis-Chalmers MOTORS

The ultimate in protection against high humidity — major cause of cooling tower motor failure — is provided tower builders and users in Allis-Chalmers TEFC motors. Here's why:

1. **Moisture drainage** — Drain plug can be removed to eliminate condensed moisture in the motor. (Particularly helpful in intermittent operations where condensation is more likely.)

2. **Extra-insulated stator** — Several applications of special insulating varnish plus repeated baking keep humidity out . . . give the long electrical life you need.

3. **Weather-protected bearings** — Rotating seal, turning in close running clearances, guards against entry of water.

Find out more about the "MORE" in Allis-Chalmers motors by contacting your nearby A-C sales office or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wis.

Outdoor Installation on jacket water-cooling units is ideal for Allis-Chalmers motors. Cast-iron frame and conduit box aren't affected by weather.

ALLIS-CHALMERS

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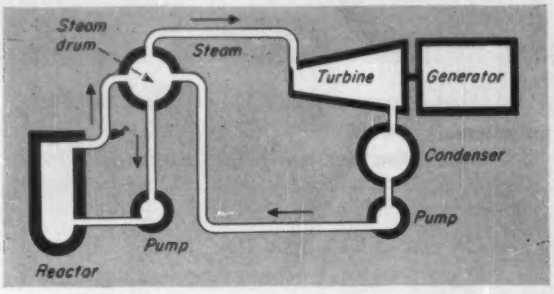
TECHNICAL BRIEFS

Latest engineering developments for busy power men

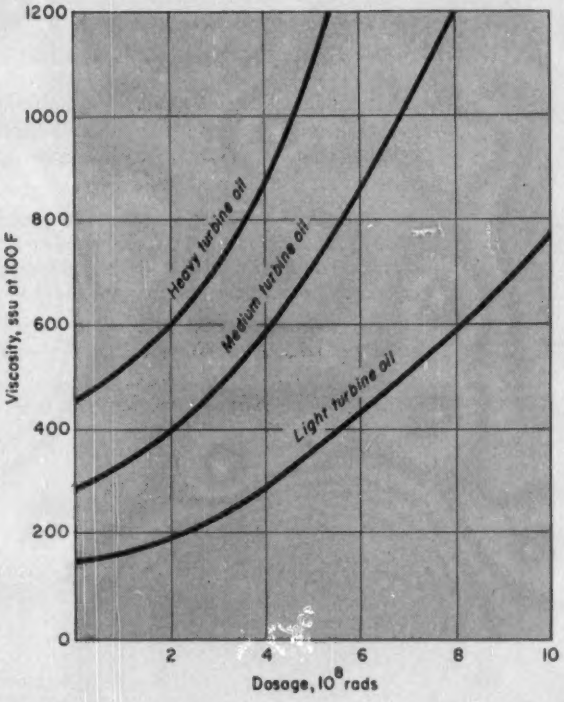
25 Papers for you on
LUBRICATION
GAS TURBINES
TRANSFORMERS
CORROSION



LUBE requirements here resemble those for ordinary plants

Radiation effects on lubricant life in a typical nuclear power plant

Components	Operating dosage level, rads/hr	Lubricant life, hours to attain 10^8 rads exposure
Turbine	0.2	10^9
Water-circulating pumps	10^3	10^6
Remote fuel-handling devices	10^5	10^3
Control drive mechanisms	10^5	10^3
At reactor vessel wall	10^6	10^2
At reactor core center	10^{13}	10^{-5}



VISCOSITY of turbine oil rises with exposure to radiation

How radiation affects petroleum lubricants

Application problems with petroleum lubricants in nuclear power plants. *By R F Hausman and E R Booser, General Electric Co.*

This paper considers the behavior of petroleum lubricants under irradiation and outlines the general problems anticipated with lubricants in the components of nuclear power plants.

Three steps are suggested to minimize lubrication problems: (1) adequate shielding between reactor and components requiring petroleum lubricants (2) careful specifications so only stable oils are used (3) relubrication schedules so oils are taken out of service before they are damaged by continued exposure.

With these steps, overall lubrication problems in a nuclear power plant will be similar to those in conventional generating stations.

Table above shows calculated radiation levels that will be encountered by lubricants in the various components of a typical single-cycle boiling water reactor plant. *ASLE paper No. 56LC-1.*

General radiation damage problems for lubricant and bearing-type materials. *By V P Calkins and C G Collins, General Electric Co.*

Radiation damage is any adverse change in the physical or chemical properties of a material or system caused by exposure to radiation. This type of damage is purely relative.

There is nothing mysterious about the general effects of radiation on lubricants or any other material. Once the cause of the effect is probed, the effects of radiation on general classes can be understood and behavior predictions can be made for materials still untested. Hence, one can theorize what materials would generally be more resistant to radiation. Actually, the effects of radiation on covalent type materials like the ordinary organic lubricants can be considered as the results of ordinary physicochemical reactions that are initiated by a somewhat extraordinary source of energy. *ASLE paper No. 56LC-2.*

Radiation resistant greases. *By J G Carrol, R O Bolt and B W Hotten, California Research Corp.*

Greases typical of those commercially available were irradiated in an atomic pile and in other radiation facilities. Specially developed experimental greases were likewise exposed. After irradiation, standard grease tests were made and results compared with data for unexposed greases. The tests

Directions for ordering papers on page 244

J-M 85% Magnesia is lightweight . . . easy for workmen to install half-sections on this 10" steam line. Insulation work at the Grace Chemical plant was performed by Young Sales Corporation of St. Louis. Engineering and construction was directed by Foster Wheeler Corporation of New York.

Your Btu's and dollars go further when you specify **Johns-Manville 85% Magnesia**

. . . the choice of insulation engineers at Grace Chemical's new Memphis plant

INDUSTRY'S LONG-TIME standard for temperatures to 600F is still your best insulation buy. For J-M 85% Magnesia provides high insulating value, easy application, long life, initial low cost and minimum maintenance. That's why insulation engineers consistently specify J-M 85% Magnesia for modern installations like Grace Chemical's new anhydrous ammonia-urea plant. That's why it will pay you to specify J-M 85% Magnesia for your new plant or modernization program.

To assure you maximum value from your insulation dollar, Johns-Manville gives you complete drawing-board-to-job-site service. You get expert recommendations by the world's most experienced insulation engineers . . . plus expert installation by authorized J-M Insulation Contractors. Write today for further information on J-M 85% Magnesia and Johns-Manville's unmatched facilities to solve your insulation problems. Address Johns-Manville Box 14 New York 16, N.Y. In Canada, Port Credit, Ontario.

J-M 85% Magnesia also comes in block form. Here you see it being applied to a vertical drum at a New Jersey petroleum refinery.

JM PRODUCTS

Johns-Manville *first-in* INSULATION

MATERIALS · ENGINEERING · APPLICATION

More TECHNICAL BRIEFS

Begins on page 164

evaluated physical properties, bearing life, oxidation, low temperature torque, copper corrosion and wear.

Radiation altered consistency. Most greases softened initially but eventually became solid. Bearing life was reduced by 40 to 90% and oxidation resistance was also severely impaired. Other properties were affected to a lesser degree. Several experimental products that gave excellent results in standard tests before irradiation showed superior radiation resistance. *ASLE paper No. 56LC-4.*

Effects of nuclear radiation on lubricants. *By J A King and W L R Rice, Wright-Patterson Air Force Base.*

A portion of the air force effort toward developing nuclear radiation-resistant lubricants is devoted to evaluating the effects of gamma radiation on specification type lubricants. Data are presented on the effects of gamma radiation on petroleum and synthetic base hydraulic fluids, lubricants, and engine oils.

Many of the materials tested appear to be satisfactory for use after exposure to about 1×10^8 roentgens of gamma radiation, the screening dosage used for these studies. To determine if a given grease is usable when subjected to nuclear radiation, more complete testing over the entire radiation range would be required. Engine lubricants and hydraulic fluids showed viscosity changes as a result of irradiation. Oxidation-corrosion characteristics of engine oils and hydraulic fluids were adversely affected by gamma radiation. *ASLE paper No. 56LC-5.*

Gas turbines

The liquid-metal fuel reactor closed-cycle gas-turbine power plant. *By L D Stoughton and T V Sheehan, Brookhaven National Laboratory.*

This paper proposes a nuclear power plant that combines advantages of a liquid-metal fueled reactor with those inherent in a closed-cycle gas turbine. The reactor fuel, a solution of uranium in molten bismuth, allows for unlimited burnup with continuous fuel make-up and processing.

The fuel can either be contained in a graphite core structure or circulated through an external heat exchanger. Cycle working fluid is an inert gas which is heated by the reactor fuel before entering the turbine. A 15-mw closed-cycle gas-turbine system is shown to illustrate the applications of this reactor. *ASME paper No. 56-GTP-12.*

El Paso's gas-turbine operating experience. *By A H Carameros, El Paso Natural Gas Co.*

This paper covers company's operating experience with 28 gas turbines from September, 1952 to January, 1956. Items covered include certain troubles in thrust bearings, gear boxes, couplings, nozzles, Christmas-tree joints, regenerators and combustion chambers. Operating problems are also covered. These are concerned with personnel training, turbine loading, lubrication, compressor fouling and dispatching.

Some interesting manpower and cost data are given, as well as fuel consumption statistics. *ASME paper No. 56-GTP-6.*

6200-kw gas-turbine-driven mobile power plant. *By Z Stanley Stys, Brown Boveri Corp.*

This paper describes design and construction of a railway-mounted mobile power plant. It contains many interesting and useful ideas on problems met when the plant must be easily moved from one site to another.

Tests of the completed unit show it is slightly larger than calculated and has a somewhat higher efficiency than expected. Standard operating temperature of the unit is 1200 F. *ASME paper No. 56-GTP-4.*

Portable 5000-kw railway and skid-mounted gas-turbine power plants. *By H H Rupp and W N Hornberger, Westinghouse Electric Corp.*

Plant described in this paper is the first mobile gas-turbine power-generating plant in this country. It is pioneering new phases of flexibility.

Maintenance costs run about $1.50 per installed kw per year. Availability records exceeding 8300 operating hours per year, including a complete plant inspection of two weeks, proves it a dependable and reliable power plant. *ASME paper No. 56-S-7.*

Development of a centrifugal compressor for a small gas-turbine engine. *By N R Balling and V W Van Ornum, Boeing Airplane Co.*

Objective of the research and development program reported in this paper was to decrease specific fuel consumption of a small gas-turbine engine by means of an increase in the pressure ratio alone.

Development of a centrifugal compressor is presented, with a special description of equipment, methods and special problems met during the tests. Results showed the required decrease in specific fuel consumption and pointed up advantages of a straightforward development program. *ASME paper No. 56-GTP-2.*

Thermodynamic performance and design of steam-gas turbine power plants. *By J W Mann Jr, General Electric Co.*

This paper deals with thermodynamic characteristics of combined steam-gas cycles. It gives practical design considerations for plants with a combined rating of about 45,000 kw.

While the author's work has been limited to consideration of plants of this size, the principles apply to plants of any rating. Where possible, means of extrapolating data is indicated. *APC paper; no number.*

Design considerations for naval gas turbines. *By G L Graves Jr, Bureau of Ships, Navy Department. ASME paper No. 56-GTP-1.*

Transformers

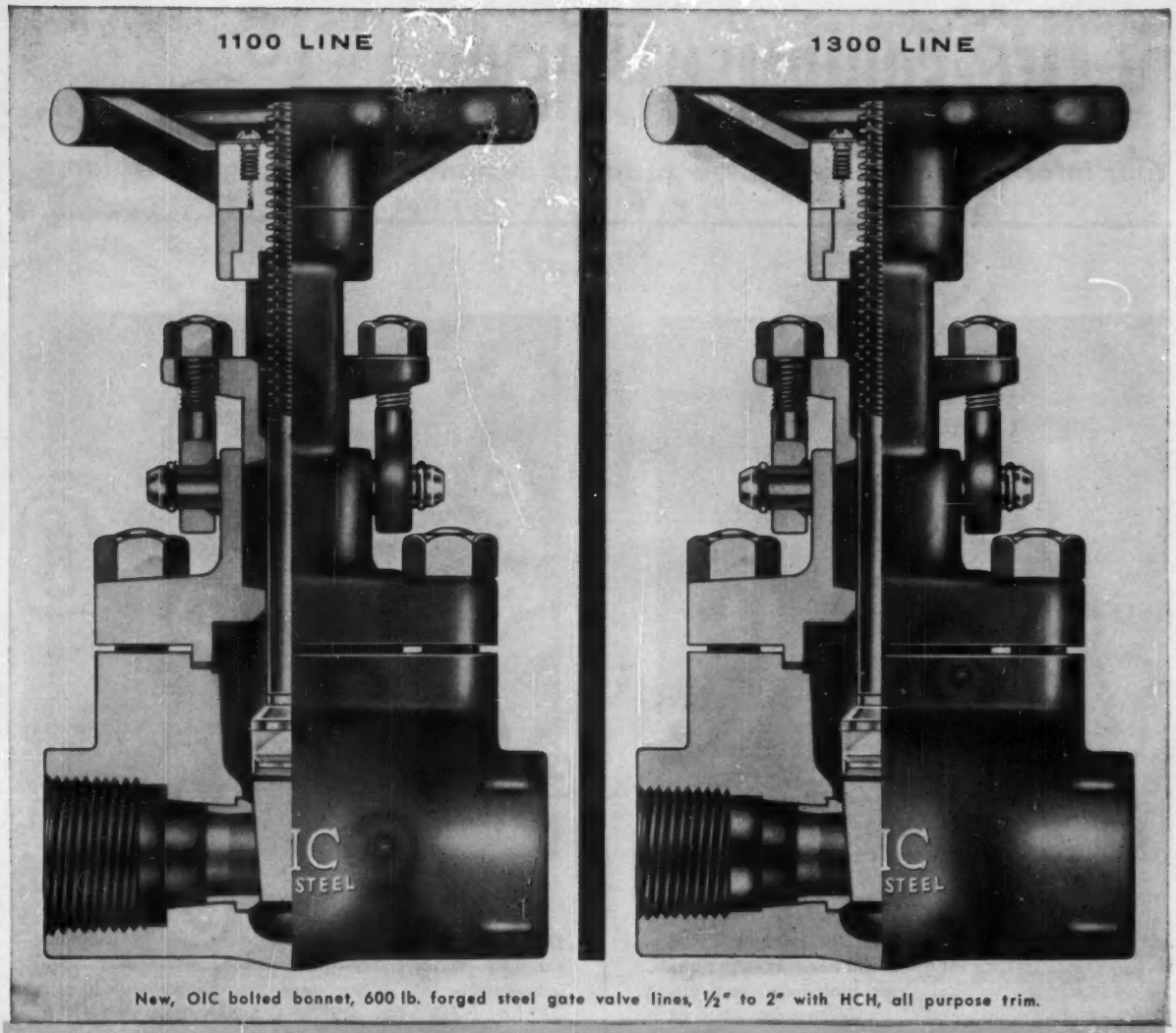
Silicones in combination with organic-based matrials for use in dry-type transformers. *By H M Broderick, A L Scheideler and G F Simmons, General Electric Company.*

The past decade has seen a major expansion in the role of dry-type transformers in electrical distribution systems. The first dry-type transformer was a ventilated unit whose major attributes were its flame resistance and reduced explosion hazard, its simplified installation, its lower maintenance, its smaller size and lighter weight. Application was limited, however, to low-voltage areas where the effect of moisture and contaminants was at a minimum.

The first major change in this original transformer was brought about by the simultaneous introduction of the high-temperature silicone-resins and the sealed dry-type. These silicone-resins used in conjunction with inorganic based materials could operate at still higher temperatures in an entirely enclosed casing. It was demonstrated, in fact, that even organic materials could

(*Continued on page* 234)

Directions for ordering papers on page 244



New, OIC bolted bonnet, 600 lb. forged steel gate valve lines, ½" to 2" with HCH, all purpose trim.

2 new rugged OIC forged steel lines

Both feature the modern and rugged bolted bonnet joint, which simplifies and lowers the cost of maintenance.

Both feature a soft iron gasket securely retained in the bolted male and female body-bonnet connection to assure enduring tightness.

Both feature 13% chrome stainless steel trim with 1000 Brinell, duracased wedges.

Both feature plenty of gripping area for pipe wrenches on pipe ends; there's no interference with body-bonnet flanges. Simplifies joint make-up!

The 1300 line includes a *high flow* port area, offering full-flow characteristics.

The 1100 line, with standard flow ports, is compact, economical, and includes the same high quality, rugged features and trim as the 1300 line.

Most valve users have applications suited to both of these new OIC valve lines. Write for Bulletin *#195-R* illustrating features and specifications that fit these newest forged steel valves to your services.

THE OHIO INJECTOR COMPANY • WADSWORTH, OHIO

VALVES | **FORGED & CAST STEEL, LUBRICATED PLUG; BRONZE & IRON VALVES**

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Your information center for new products designed to solve plant problems

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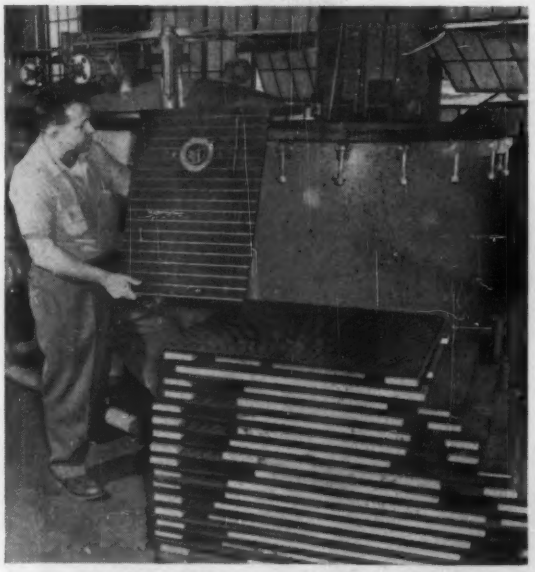
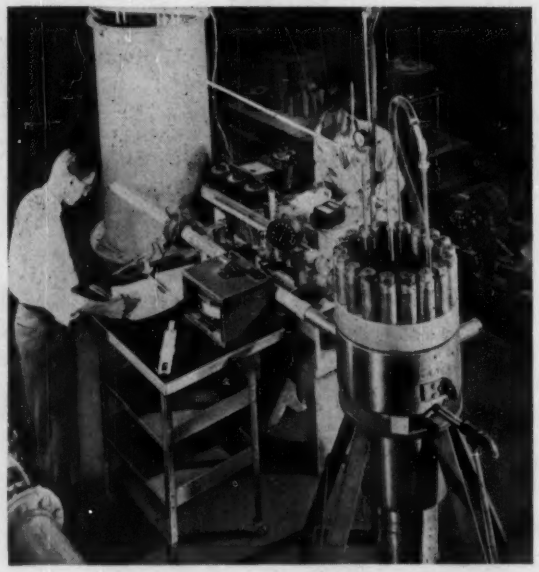


Filter leaves withstand corrosion

1201 • Filter leaves molded from *Hycar* rubber are suitable for use with both corrosive and non-corrosive liquids. Manufacturer claims that these filters are particularly convenient to use in parallel for large jobs, since each can be dropped out for cleaning without interfering with other units. Sizes range from 6x12 to 30x48 in.

Industrial Filter & Pump Mfg Co, 5916 Ogden Avenue, Chicago, Illinois

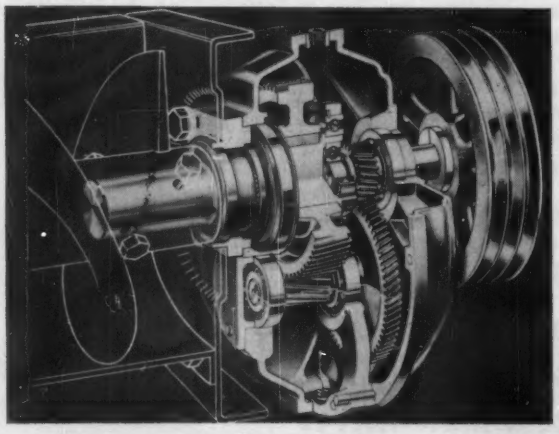


Centrifugal blower handles toxic gases

1202 • Leak-proof centrifugal blower may be used for handling corrosive, toxic and radioactive gases at high temperatures and system pressure. Blower will handle 20 cfm of gas with sp gr of 6 and will develop 150-ft head in a 2000-psi system. Unit operates at gas temperatures up to 500° F. To facilitate inspection, blower is arranged so all rotating and bearing parts can be removed.

Allis-Chalmers Mfg Co, 864 S 70th St, Milwaukee 1, Wis.

For more data on these items, use post cards on page 177. Identify your request with item number

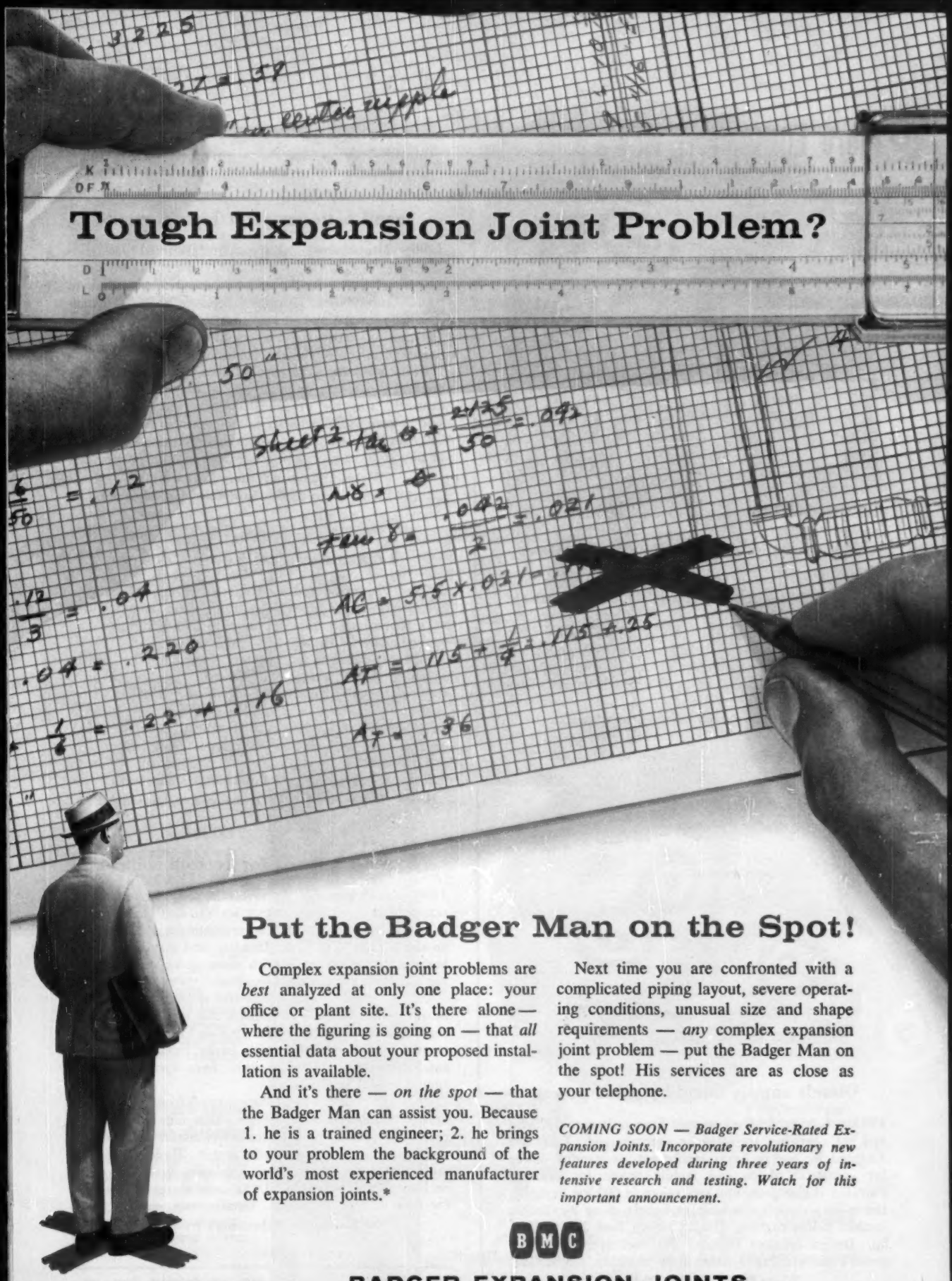


Speed-reduction unit for screw conveyors

1203 • Speed-reduction unit is designed for screw conveyor applications. Unit has flange adaptor that permits bolting directly to trough end of screw conveyor. Output shaft fits into end of pipe of standard 6, 9 or 12 in. screw having a bore of 1½, 2, 2 7/16 in. Input shaft of unit is driven from motor of any make, type or age, by short center V-belt drive.

Unit is bolted directly to trough end and eliminates any tendency to wobble which might occur when other drive components are mounted on extended screw with its loose tolerance fit in a screw conveyor pipe. Unit can be successfully used to drive inclined screw conveyors where angle of inclination or declination is up to 20 deg above or below horizontal. Unit comes in three sizes from ½ to 10 hp.

The American Pulley Co, 4200 Wissahickon Ave, Philadelphia, Pa.



Put the Badger Man on the Spot!

Complex expansion joint problems are *best* analyzed at only one place: your office or plant site. It's there alone — where the figuring is going on — that *all* essential data about your proposed installation is available.

And it's there — *on the spot* — that the Badger Man can assist you. Because 1. he is a trained engineer; 2. he brings to your problem the background of the world's most experienced manufacturer of expansion joints.*

Next time you are confronted with a complicated piping layout, severe operating conditions, unusual size and shape requirements — *any* complex expansion joint problem — put the Badger Man on the spot! His services are as close as your telephone.

COMING SOON — Badger Service-Rated Expansion Joints. Incorporate revolutionary new features developed during three years of intensive research and testing. Watch for this important announcement.

*Badger has been solving tough expansion joint problems for 50 years — a record unmatched by any other firm.

BADGER EXPANSION JOINTS

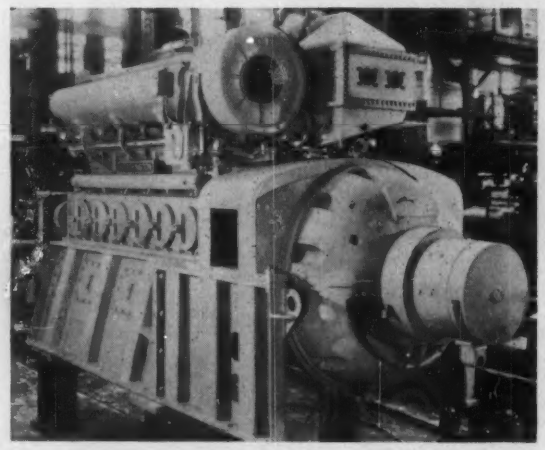
BADGER MANUFACTURING COMPANY

230 Bent Street, Cambridge 41, Massachusetts • 60 East 42nd Street, New York 17, New York

Representatives in principal cities

More EQUIPMENT NEWS

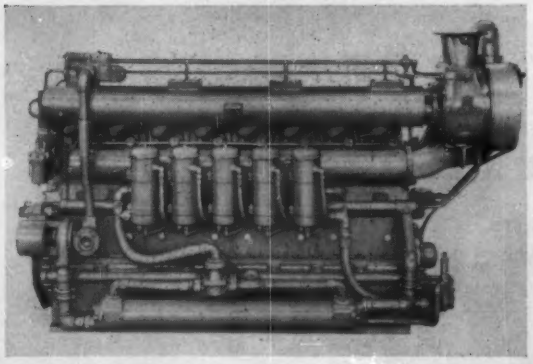
Begins on page 168



Heavy-duty engine for auxiliary power

1204 • *W9 Engine* acts as source for auxiliary or main power at peaking or continuous levels for industrial and institutional power requirements. *W9* is small, heavy-duty, four cycle unit with 400-1400 hp. Fully assembled upon delivery, unit is ready to be placed upon its foundation, requires no major aligning. Constructed for continuous operation, unit has been designed for high output turbo-supercharged operation. Air is swirled as it enters cylinder. According to manufacturer, this assures rapid mixture of air and fuel, and efficient, clean combustion.

Worthington Corp, P.O. Box 953, Buffalo 5, N. Y.



Diesels supply stand-by plant power

1205 • Industrial diesel engines have ratings to 1025 hp and are available aspirated or supercharged. Units are designed for use in heavy equipment, as standby power for industrial plants and mobile power for utilities. Portable engine-generator sets range to 600 kw capacity. Heavy-duty models are built as 4-cycle, 6- or 8-cylinder, vertical in-line engines. Output ranges from 215 to 1025 hp. Design features include: dual-fuel operation, compressed air starting system, open chamber combustion.

White Diesel Engine Division,
White Motor Company, Springfield, Ohio

Small batteries yield high currents

1206 • Miniaturized nickel cadmium sintered plate storage batteries range in sizes smaller than a cigarette lighter and from ½ to over 150 amp-hr capacity. According to manufacturer, they provide exceptionally high instantaneous currents, and so are valuable for switch tripping and closing particularly in compact unattended substations and in severe climatic conditions.

Units are said to be capable of delivering momentary discharge currents as high as 25 times rated amp-hr capacity. Capable of repeated cycle service, they are said to have useful capacity in temperatures ranging from –40 F to +165 F. It is possible to store them indefinitely in any state of charge without deterioration or freezing.

Nickel Cadmium Battery Corporation,
68 Pleasant Street, Easthampton, Massachusetts

Transmitters utilize new design

1207 • Pneumatic and electric transmitters for use with rotameters utilize design features which manufacturer says represents a new approach to standardization and in-the-line performance.

Pneumatic transmitter employs direct force balance to minimize mechanical motion. According to manufacturer, this provides low inertia characteristics and improved response time. Three screwdriver adjustments take care of range, linearity and zeroing. Electric transmitter utilizes proven strain gage element. Standard model is explosion-proof according to manufacturer. Unit is applicable to automatic logging and data reduction equipment.

Brooks Rotameter Co, 47 Dennison Ave, Lansdale, Pa.

Gearmotor used for remote control

1208 • Shaft-mounted gearmotor is designed to provide remote and automatic control for variable-speed drives, valves, pumps, feeders and other machines. Unit mounts on shafts from ¼ to ⅞ in. diameter, and may be mounted horizontally or vertically with shaft up or down. Housing and cover are made of aluminum.

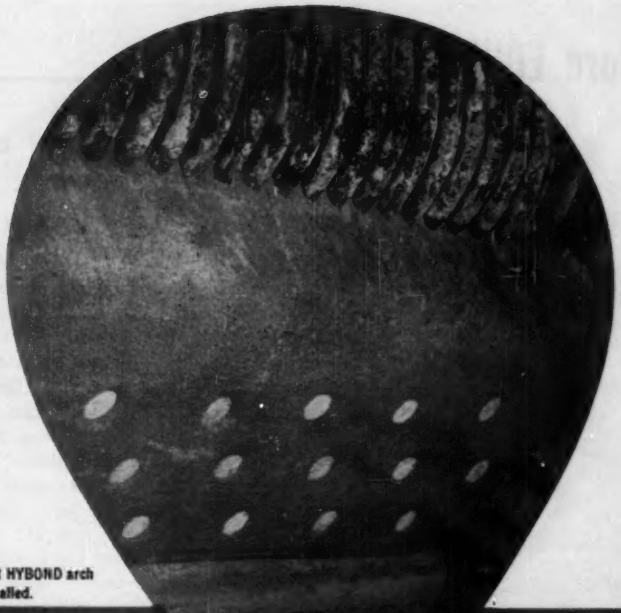
Unit is furnished with torque arm or plate with resilient mounting that absorbs any runout that may be present in shaft to be controlled. When used on rising stem valves, torque plate is equipped with linear bushings to allow axial movement. Standard units have speeds from ½ rpm to several hundred rpm.

Units are available to produce torques from a few in.-oz. to several hundred in.-lb. Single phase units use instantly reversible permanent split-capacitor motor having high-starting torque with low inrush current. Three-phase units are available in larger sizes. Explosion-proof and other enclosures are available. Units can also be furnished for face or foot mounting. Details from manufacturer.

The Jordan Co, Milwaukee, Wisconsin

For additional information on these new equipment items, use post cards on p 177. Identify your request with item number.

A SUPER HYBOND arch was installed in a B & W coal fired boiler, with a chain grate stoker, in an Indiana Municipal light plant. The boiler is rated at 125,000 lbs. per hour, and operates at about 200% of rating. Prior to the use of SUPER HYBOND it was necessary to replace the arch in this boiler every 9 months. The SUPER HYBOND arch was not replaced for 3½ years and even then, as shown by the photos, could have given additional service.



SUPER HYBOND arch as installed.

A.P. GREEN

Super Hybond Suspended Arch Gives More Than Twice the Service of Previously Used Refractory Arch

SPECIFY A. P. GREEN PLASTIC FIREBRICK LININGS for longer life... lower maintenance costs

For over 30 years, A. P. Green plastic firebrick, made from highest quality Missouri fire clays, has been proved in service. Four grades of plastic to meet varying refractory needs.

warehouse stocks for prompt shipment

Look in the classified section of your telephone directory or write direct for the name of the A. P. Green distributor in your locality. He has complete stocks and can make prompt delivery.

SUPER HYBOND arch after 3½ years' service.

A. P. Green
REFRACTORY PRODUCTS

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

PLANTS: Mexico, Mo. • Woodbridge N. J. • Sulphur Springs, Texas
IN CANADA:
A. P. Green Fire Brick Company, Ltd., Toronto 15, Ontario

More EQUIPMENT NEWS

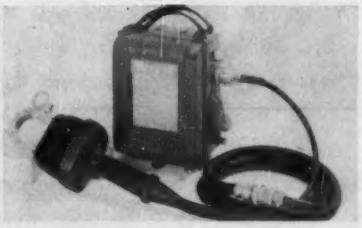
Begins on page 168

The right meter or gage can make a big difference

Liquid flowmeters

1210 • Crank-controlled liquid meters are designed for larger capacity, longer life, quiet operation and reduced maintenance costs, according to manufacturer. Meters feature crank-type linkage for gear control. Three models have flow capacities ranging from 400 to 1000 gpm. According to manufacturer, linkage cuts down number of parts, makes for stronger control of vane positioning and therefore increases capacity and life expectancy. When back cover bolts and cover are removed and meter axial adjustment nut is unlocked, rotor can be pulled from meter case. Repair costs are said to be negligible. Requet bulletin.

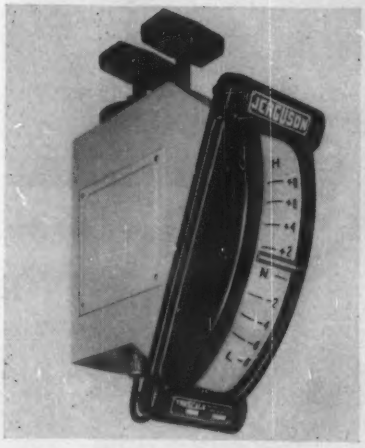
Rockwell Mfg Co, Meter and Valve Div, 400 N Lexington Ave, Pittsburgh 8, Pa.



Portable volt-ammeter

1211 • Two standard ranges have been added to *Type-CF-7* portable recording hookon volt-ammeter to increase flexibility. New current ranges are 30 and 300 amps. This provides recorder with six current ranges 15, 30, 75, 150, 300 and 750 amps and three voltage ranges 150, 300 and 750 volts ac.

General Electric Co, Schenectady 5, New York

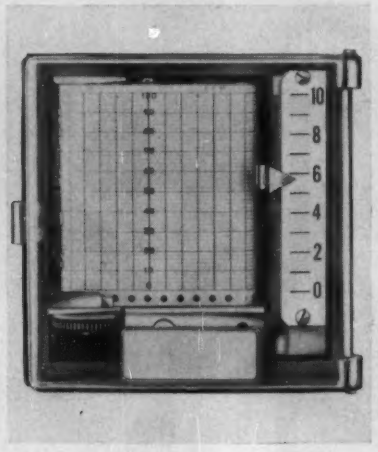


Liquid level gages

1212 • Remote reading liquid level gages are inclined for use where gages have to be mounted high or low on instrument panel. For high installations, case is built so cover and scale incline downward; for low installations cover and scale incline upward.

Units give instant remote reading of liquid levels in boilers and tanks with accuracy of ½ of 1% of scale reading. They bring liquid level to where it can easily be seen. Convex faces give 180 deg visibility. Request full details.

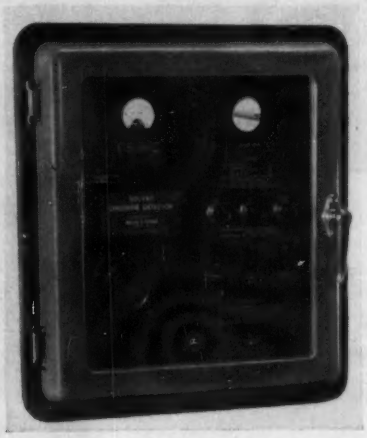
Jerguson Gage & Valve Co, 80 Fellsway, Somerville 45, Mass.



Electronic potentiometer

1213 • Self-balancing electronic potentiometer gives continuous record on 3-in. strip chart. Recorder, which uses standard components, is housed in case 5-in. sq. Small-size self-balancing instruments are furnished in indicating models also. Indicating and recording chassis are built for full plug-in service. Units available in either potentiometer or ac bridge models, can be used to measure and indicate or record any variable which can be converted into an electrical quantity, such as temperature, pressure, flow, speed.

The Bristol Co, Waterbury 20, Conn.



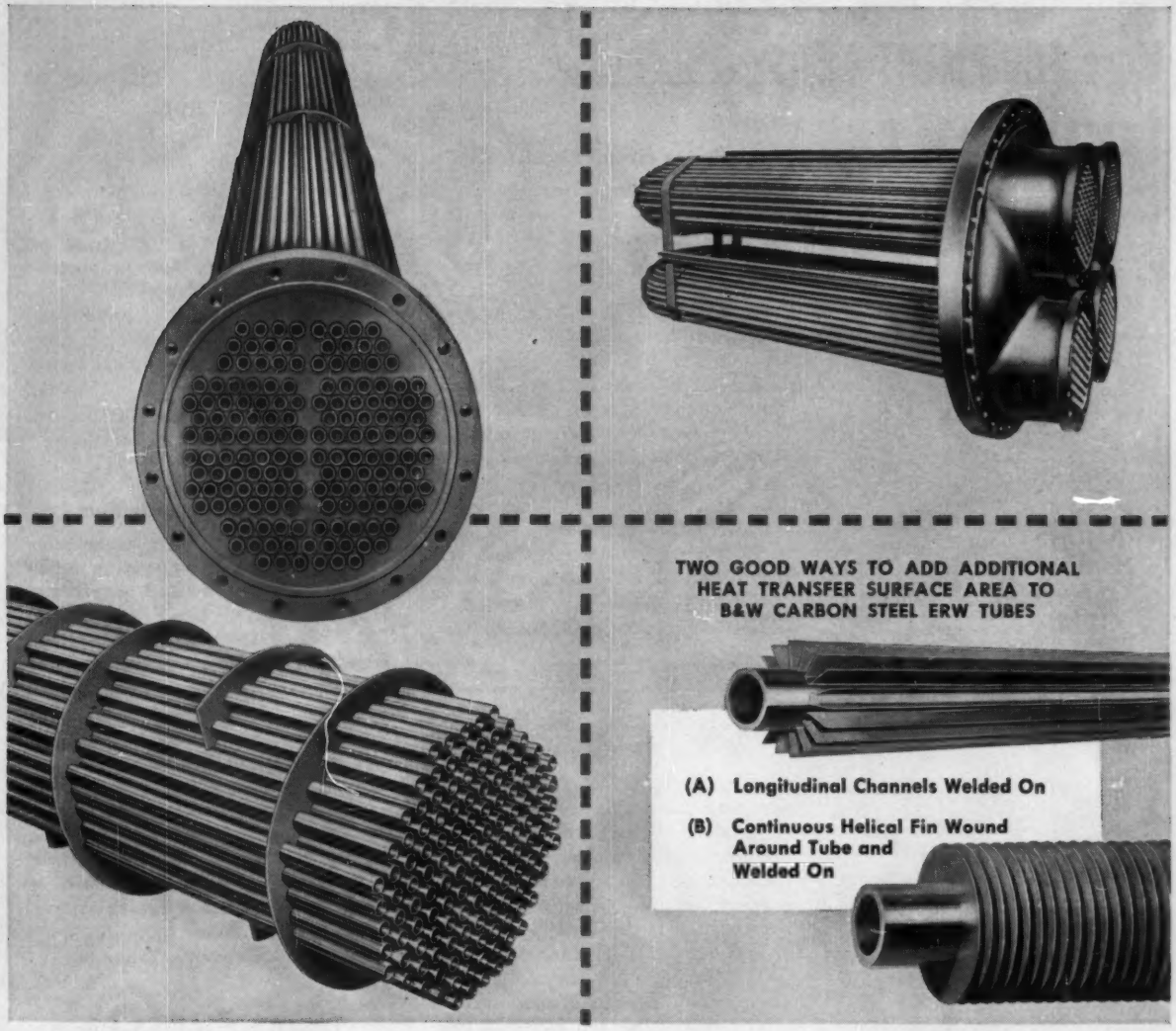
Chlorine detector

1214 • *Series A-689* detector is said to detect three parts chlorine in a million parts of air. Manufacturer claims that sensitivity of the detector allows unit to give warning of presence of chlorine in air long before a throat-irritating concentration of 15 parts per million is present.

Detector is electrically operated with alarm signal resulting from reaction of chlorine gas with chemically-treated dry paper. Unit is made for either wall or panel mounting.

Wallace & Tiernan, Inc, 25 Main St, Belleville 9, N. J.

For more data on these items, use post cards page 177. Identify your request with item number.


TWO GOOD WAYS TO ADD ADDITIONAL HEAT TRANSFER SURFACE AREA TO B&W CARBON STEEL ERW TUBES
(A) Longitudinal Channels Welded On
(B) Continuous Helical Fin Wound Around Tube and Welded On

TUBING REQUIREMENTS FOR HEAT TRANSFER EQUIPMENT

The economy and usefulness of pressure tubing in heat exchanger and condenser applications depend on the tubing's heat transfer ability and the ease with which it can be bent, coiled, swaged, and rolled into tube sheets.

Because of its uniform wall thickness, the heat transfer ability of B&W Electric-Resistance-Welded Carbon Steel Tubing is the optimum for such a ferrous material. It is an economical material to use, not only because of its reasonable first cost, but also because of its low fabrication cost, since ease of bending, coiling, swaging, and rolling into tube sheets is provided through quality-controlled methods used in its manufacture.

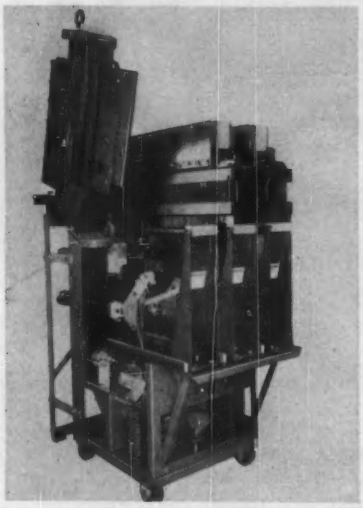
B&W Electric-Resistance-Welded Carbon Steel Heat Exchanger and Condenser Tubing is widely used in the process industries, including petroleum refining and chemical processing, and in refrigeration and steam generating equipment. If carbon steel tubing can do the job required, you will find B&W ERW Tubing provides maximum, trouble-free service life. For additional information, call on Mr. Tubes, your nearby B&W Tube Representative — *or write for Bulletin 412.* The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

TA 6099-GP

Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy, and stainless steels

More EQUIPMENT NEWS

Begins on page 168

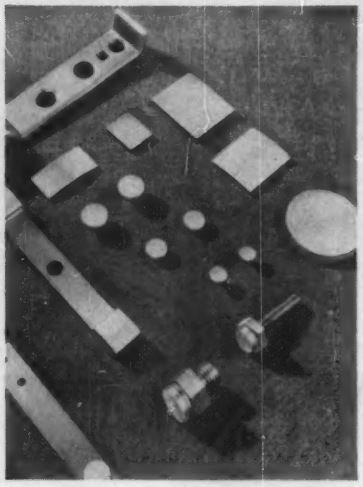


Power circuit breakers

1215 • Anticipating three new higher industry standard ratings for metalclad switchgear, manufacturer has developed and tested power circuit breakers for all three ratings.

For 13.8 kv, 1200 and 2000 amp applications, units, designated *15HV-750*, are available with interrupting rating of *750 mva*. Circuit breakers, *5HV-350* have higher interrupting rating of 350 mva and continuous current rating of 3000 amps for mains and bus ties; 1200 amps for feeders. Also for 4.16 kv, 1200 amp applications, circuit breakers, *5HV-75*, with interrupting rating of 75 mva are available. Request complete details direct from manufacturer.

I-T-E Circuit Breaker Co, 19th & Hamilton Sts, Philadelphia 30, Pa.



Electrical contacts

1216 • Electrical contacts are able to withstand larger currents than silver or its alloys without welding or sticking, manufacturer states.

Containing silver and cadmium oxide, contacts are said to cause significant improvement in life and performance of many electrical products when substituted for silver or silver alloys. In others, units provide greater current-carrying capacities and increased electrical ratings. According to manufacturer, they have excellent arc-quenching traits and low contact resistance. Applications include motor-starting and limit switches, industrial controls, etc.

Gibson Electric Company, Frankstown Ave, Pittsburgh 21, Pa.

Enclosed circuit breakers

1217 • *AB-I* enclosed circuit breakers, *Type E, F* and *J*, provide plug-in ratings from 15 to 225 amps in only two NEMA 1A general purpose enclosures. Two additional enclosures are designed for conventional bolted-in *Type K, KL* and *L* frame breakers. According to manufacturer, advantages include visible disconnect safety; minimum downtime and maintained productivity due to ability to carry temporary light overloads. Request complete information direct from the manufacturer.

Federal Pacific Electric Co, 40 Paris St, Newark 1, N. J.

Electronic controls

1218 • Unitized *Autronic* controls are based on principle of instantaneous all-electronic control. According to manufacturer, unitizing of *Autronic* controls has resulted in a number of advantages: controller, recorder (or indicator) and manual control are of plug-in construction; wiring between individual instruments eliminated. Details on request.

The Swartwout Co, 18511 Euclid Ave, Cleveland 12, Ohio

Thermostatic controller

1219 • Pilot-type thermostatic controller for higher temperature applications comes in standard temperature ranges of 250 to 450 F, and 350 to 550 F. Controller measures 3 13/16 in. wide, 19¾ in. long and is recommended where compressed air is used as pilot supply.

Thermosensitive tube is made of stainless steel to withstand corrosion as well as temperature and erosion. Finned thermal isolator section keeps pilot valve and adjustments cool on high-temperature control applications. Unit may be installed horizontally or vertically. Details from manufacturer.

Robertshaw-Fulton Controls Co, Box 400, Knoxville, Tennessee

Digital demand recorder

1220 • Digital demand recorder automatically produces punched tape record of watt-hour demands. Punched tape record can be read visually or processed by a tape translator operating a card punch. Recorder operates from standard contact-making mechanism on watt hour meter. Unit has few close tolerances. Request further details.

Fischer & Porter Co, 848 Jacksonville Rd, Hatboro, Pa.

For more data on these items, use post cards p 177. Identify your request with item number.

Check these too . . .

Air interrupter switch . . . . . p 182
Condensate return pumps . . . . p 182
Silicon rectifier stacks . . . . . p 184
Engine generator plants . . . . . p 186
Temperature regulator . . . . . p 186
Piston pressure switch . . . . . p 188
Automatic gas valves . . . . . p 190
High pressure regulator . . . . . p 190

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ANCHOR COMBINED PURE ASBESTOS GRAPHITE BUNA N

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This packing—CARBONITE #820 N. J.—has the greatest range of uses of any packing known: Steam and Air . . . Chemicals . . . Acids . . . Solvents . . . Water . . . Oil . . . Gasoline.

It is 100% pure asbestos, graphite and Buna N. Perfectly formed rings of any diameter are easily cut from the spirals. No die-forming is required.

"N. J." means "No Jacket." This superior packing is supplied in spiral or ring form in sizes from 3/16" square up to 1" square.

Write us today for further details on this packing-of-a-thousand-uses.

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FIBROUS AND METALLIC PACKINGS FOR EVERY INDUSTRIAL PURPOSE

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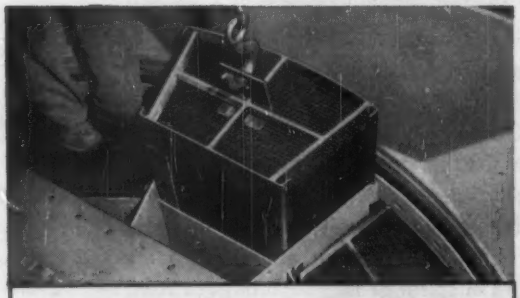

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- Size for size, recovers more heat than any other type.
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- Eliminates cold spots...keeps corrosion to a minimum.
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MINIMUM CORROSION is an important reason. There are no cold spots in a Ljungstrom. Temperature is uniform on all heating surfaces—corrosion-causing condensation is reduced.

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The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

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AIR CONDITIONING, VENTILATION

1 **Cooling towers** for industrial application where process water temperatures are critical, are described in 8-p bulletin 203. Describes 44 sizes available, gives complete selection data. Baltimore Aircoil Co, Inc, 2624 Mathews St, Baltimore 18, Md.

2 **Centrifugal fans.** Illustrated 8-p catalog 4824 discusses performance features and construction details of Airfoil fans. Contains data on several possible volume control methods that can be used with the units. American Blower Corporation, Detroit 32, Mich.

3 **Power exhausters,** axial mushroom-type, are described in 4-p bulletin CAM-103. Contains performance tables, photos, and application info. Unit exhausts 350 to 34,430 cfm of fumes, smoke and dust. Chicago Blower Corp, 9863 Pacific Ave, Franklin Park, Ill.

4 **Ventilating** and heating line offers 72 coil capacities and coil arrangements in six different sizes. Output ranges from 1500 to 32,000 cfm and 47,000 to nearly 2,000,000 Btu. Illustrated 12-p bulletin 46PQRV-72 contains charts, tables showing hot-water and steam ratings, fan performance. Carrier Corp, Syracuse, N. Y.

5 **Heavy-duty fans,** Classes II, III, IV, for ventilating and industrial applications are described in 20-p bulletin F-200. Contains photos, performance charts of various sizes. Buffalo Forge Co, Buffalo, N. Y.

6 **Dust collectors.** Industrial cloth-filter-type units are described in illustrated 4-p bulletin 557-D. Includes two case histories, full specs. Wheelabrator Corporation, 343 S Byrkit St, Mishawaka, Ind.

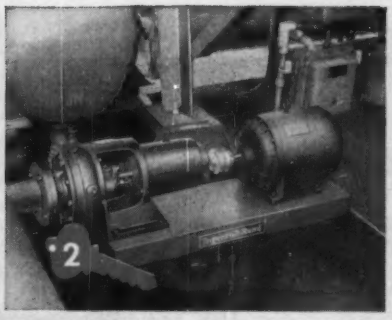
BOILERS AND AUXILIARIES

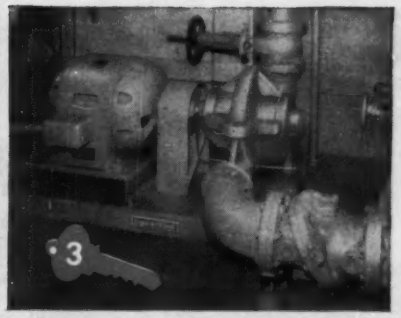
7 **Packaged boilers.** Automatic *Power-Pak* units in capacities from 8 to 25 hp, for pressures to 15 psi, are described in 4-p bulletin 1233. Equipped with either oil- or gas-firing burners. Orr & Sembower, Inc, Morgantown Rd, Reading, Pa.

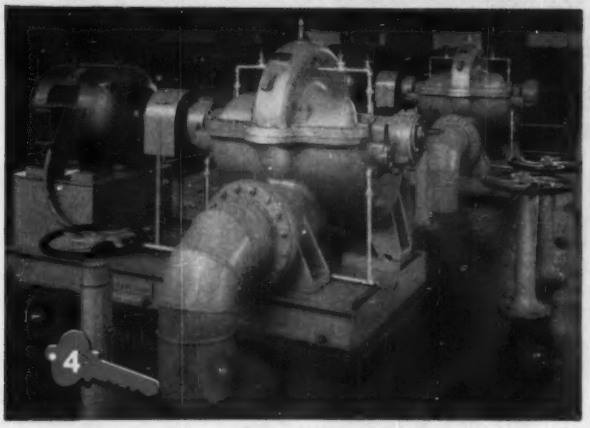
8 **Boiler installations** around the world, is subject of 4-p bulletin. Also points out advantages of *Progress* packaged boiler designed for commercial heating up to 1,340,000 Btu/hr. Cleaver-Brooks Co, 326 E Keefe Ave, Milwaukee 12, Wis.

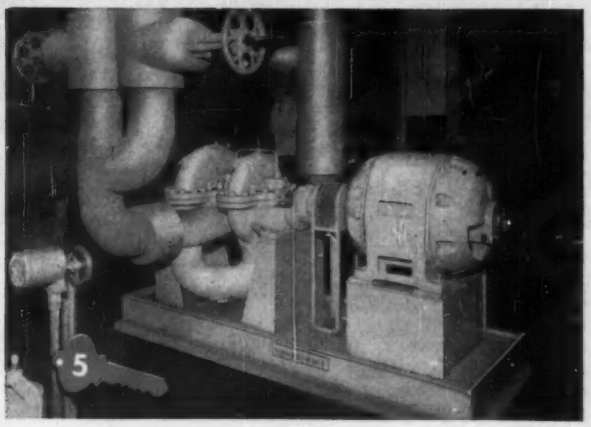
9 **Box furnaces** are described in 4-p bulletin GEC-1402. Includes specs, temperatures, ratings, dimensions of units with cooling chambers, for low production and laboratory use. General Electric Co, Schenectady, N. Y.

(*Continued on page* 218)









Five Keys to LONG-RANGE ECONOMY on your general-purpose pumping jobs

The Ingersoll-Rand pumps shown feature several different designs and types. Yet they all have one thing in common—the ability to give you low-cost performance on your general purpose pumping jobs.

When you install an I-R pump, you can count on continued efficient operation—with a minimum of time out for attention and maintenance.

In addition to the pumps shown, Ingersoll-Rand manufactures a complete line of single and multi-stage pumps of horizontal and vertical design for every job application. See your I-R representative for full information on the pump which best meets your needs.

1. MOTORPUMPS: Free from base plates, couplings and alignment problems, I-R Motorpumps can be mounted in any position that gives the simplest, most economical installation. They are especially designed for continuous full load service, with a wide range of capacities from 5 to 1800 gpm and heads up to 600 ft. Available in single, two and four-stage units.

2. CRADLE-MOUNTED PUMPS: Built with separate pump and drive units, coupled and mounted on a sturdy base plate, I-R Cradle-Mounted Pumps come in one and two stages, with capacities from 5 to 2800 gpm and heads up to 525 ft. They can be equipped with any drive, and provide easier accessibility, over-sized bearings and greater accessibility.

3. SINGLE-STAGE HORIZONTALLY-SPLIT PUMPS, with double mechanical shaft seals: For capacities from 275 to 2400 gpm and heads to 350 ft., maintenance-free DMV and DHV pumps are provided with double mechanical shaft-seals and permanently lubricated sealed bearings. Troublesome stuffing box maintenance is eliminated, and bearings do not require any attention or lubrication throughout the life of the pump.

4. SINGLE-STAGE HORIZONTALLY-SPLIT PUMPS, conventional design: The Class AFV unit illustrated is typical of the standard I-R line of single-stage horizontally-split centrifugals, with capacities ranging from 25 to 50,000 gpm, and heads from 20 to 350 ft. Stuffing boxes are extra deep, and equipped with water seal cages. Any type of drive may be used.

5. TWO-STAGE HORIZONTALLY-SPLIT PUMPS: I-R two-stage Class GT pumps are available in capacities up to 2200 gpm for discharge heads up to 1050 ft. Outstanding performance is assured by such features as extra deep stuffing boxes, renewable shaft sleeves and wearing rings, carefully designed liquid passages and volutes, and efficient closed-type impellers.

Ingersoll-Rand

10-455 11 Broadway, New York 4, N. Y.

PUMPS • ROCK DRILLS • GAS & DIESEL ENGINES
COMPRESSORS • CONDENSERS • AIR & ELECTRIC TOOLS

George Edwards

believes it's a matter of design

► I GUESS I'D BE SAFE in saying that most people look through a magazine in pretty much the same way. Generally, I skim through the pages, make a mental note of what I'll read first, what to save for later, and take a gander at the ads.

In technical magazines, some of the advertisements are chunks of useful information, such as the "how it works" with a drawing of a device, or maybe a maintenance hint that gives a plant man a lift.

I once mentioned this to Lou Rowley during one of my visits to the McGraw-Hill Building. Lou told me it wasn't uncommon to get a letter from a POWER reader saying nice things about the ads as well as the editorial pages.

In fiction magazines, too, that come to our house, the ads are colorful and attractive. They have to be these days to get the company's product under the public's eye.

They show pictures of smiling families grouped around a new car, a washing machine, or a television set. In pointing up our wonderful standard of living the ads seem to say that if we possess these things we'll be *happy*.

Naturally, we all want the best things in life for ourselves and our loved ones, including a share of material things that give us pleasure and lighten our daily labor. But when it comes to *happiness*, there isn't a machine or assembly line in the world that can produce it.

Our forefathers sure knew what they were doing when they coined the phrase "life, liberty, and the pursuit of happiness." They knew that no law or edict could guarantee a man's happiness; they just wanted to get rid of the roadblocks when he set out to find it.

They knew that a man could become as rich as Croesus, as powerful as Caesar, as free as a bird—but if he never got hold of the one item he couldn't buy, command, steal, or capture by force, he'd never be a *happy* man. The item has a name—in fact, a couple of names—familiar to all of us. Some call it *contentment*, some call it *peace-of-mind*, but by either name it adds up to *happiness* and it's free to rich and poor alike.

Nobody will ever develop a pat formula for happiness. I guess people have written a zillion words telling other people how to be happy, but, for my money, it's something each guy has to discover for himself.

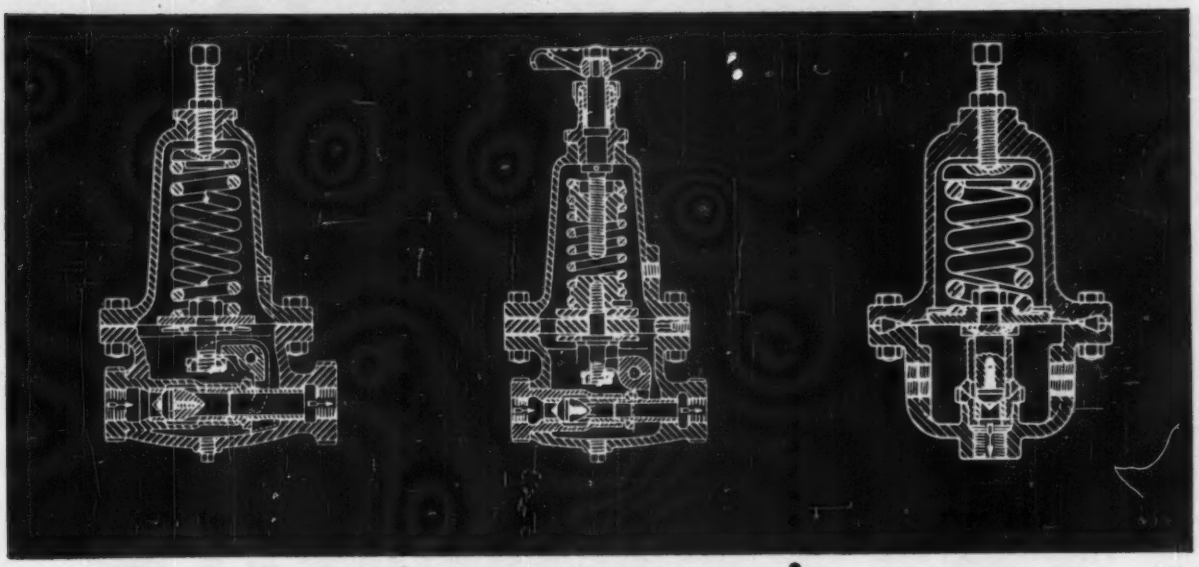
As the Christmas season approaches, we're all going to hear again the familiar, gentle phrase, "peace on earth, to men of good will." During most of my life, I believed that "peace on earth" meant absence of war and strife. But now, I like to feel it means the peace that fills a man's heart when he's *happy*, in the true sense of the word. And *happy* people don't wage war.

YOUR CONTROL PROBLEM?

You'll find the Answer in

CASH STANDARD

Steam . . . Water
Air . . . Gas . . . Oil
} **REGULATORS FOR POWER** {
☑ GENERATION
☑ DISTRIBUTION



PRESSURE REDUCING VALVE

A streamlined high capacity valve for close pressure regulation—accurate even under toughest working conditions. Closes against the flow, eliminating conditions that cause chatter. Two types available: for high pressures and for low pressures. Recommended for steam, water, air, oil and most gases and chemicals. Screwed ends, sizes: ¼" to 2".

DIFFERENTIAL CONTROL VALVE

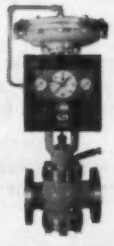
Maintains constant differential pressure between atomizing steam and fuel oil. Non-rising type adjusting screw adjusts spring either under tension or compression for maintaining steam above or below fuel oil pressure, depending on type of burner employed. Iron, bronze or steel body; bronze or stainless steel trim. Screwed ends, sizes ¼" to 2" with expanded outlets when desired.

RELIEF VALVE

Maintains a desired inlet pressure by relieving into relief line provided or protects equipment against high pressure line surges. For water, oils, air, gases, slurries and many other fluids. Bottom connection is outlet or discharge connection. Two side inlet connections permit installation in the line or as an angle valve with one side inlet plugged. For relief pressures to 325 lbs. and temperatures to 500° F. Screwed ends, sizes: ¼" to 2"; flanged ends, size ½".

Cash Standard
Stacon Series V Self Operating Temperature Regulators

Type 57
Recording Controllers



Type 30
Diaphragm Control Valve With Type 51 Indicating Controller Mounted

Type 44
Pilot Operated Pressure Regulator

Type 100
Positioning Controller

Contact the Cash Standard control specialist in your area or write Dept. E

CASH (CS) **STANDARD**

A. W. Cash Co. and Its Subsidiary, Cash Standard Stacon Corp.
P. O. Box 551, Decatur, Ill.

PRESSURE, HYDRAULIC, TEMPERATURE, PROCESS AND COMBUSTION CONTROLS

POWER
SPECIALISTS!
KULJIAN HAS DESIGNED, ENGINEERED, AND SUPERVISED CONSTRUCTION OF POWER PLANTS THE WORLD OVER . . . WITH TOTAL ELECTRIC GENERATING CAPACITY EXCEEDING
2,000,000 KILOWATTS!

Vast power projects throughout the world—more than seventy in all—attest to The Kuljian Corporation's reputation as SPECIALISTS IN THE POWER FIELD. These power plants, with capacities ranging from 2,500 to 240,000 KW, represent a total investment of over half a billion dollars.

No matter what type of power project you are planning . . . be it steam, hydro, or diesel . . . Kuljian's wealth of practical experience, backed by a complete staff of internationally recognized engineers, can serve you quickly, economically, and efficiently to meet your specific requirements.

Next time *you* need outside help, why not contact a Kuljian engineer for preliminary consultation. He will be glad to provide the help you need, anytime . . . anywhere.

ACTUAL ON-THE-JOB REPORTS are continually received at Kuljian headquarters. From these reports, easy to read case histories are developed into articles that are published by editors of leading magazines.

If you are interested in knowing more about us . . . how we work, what we have done for others . . . your request for literature will be most welcome.

The **Kuljian** *Corporation*

engineers • constructors

1200 North Broad Street • Philadelphia 21, Penna.

BRANCH OFFICES THROUGHOUT THE WORLD

More EQUIPMENT NEWS

Begins on page 168

Air interrupter switch

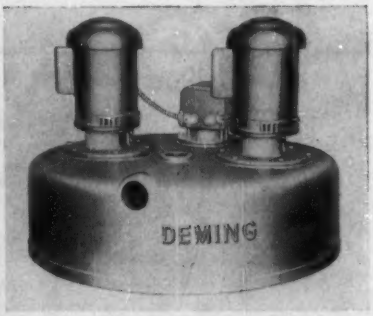
1221 • This high-voltage air interrupter switch functions as an air break disconnect with continuous and interrupting ratings to 600 amps at 15 kv. Designed to be safely opened under load, switch is said to interrupt all currents to its continuous rating.

Three front operated 3-pole types are available: single throw, non-fused, wall-mounted; single throw, fusible, free-standing; double throw, fused or non-fused, free-standing.

Combined with power fuses, switches are said to offer full circuit protecton where automatic restoration of service is not required. Details from manufacturer.

Continental Electric Equipment Co, 205 W 4th St, Cincinnati, Ohio

For more details on these items, use post cards p 177. Identify your request with item number.

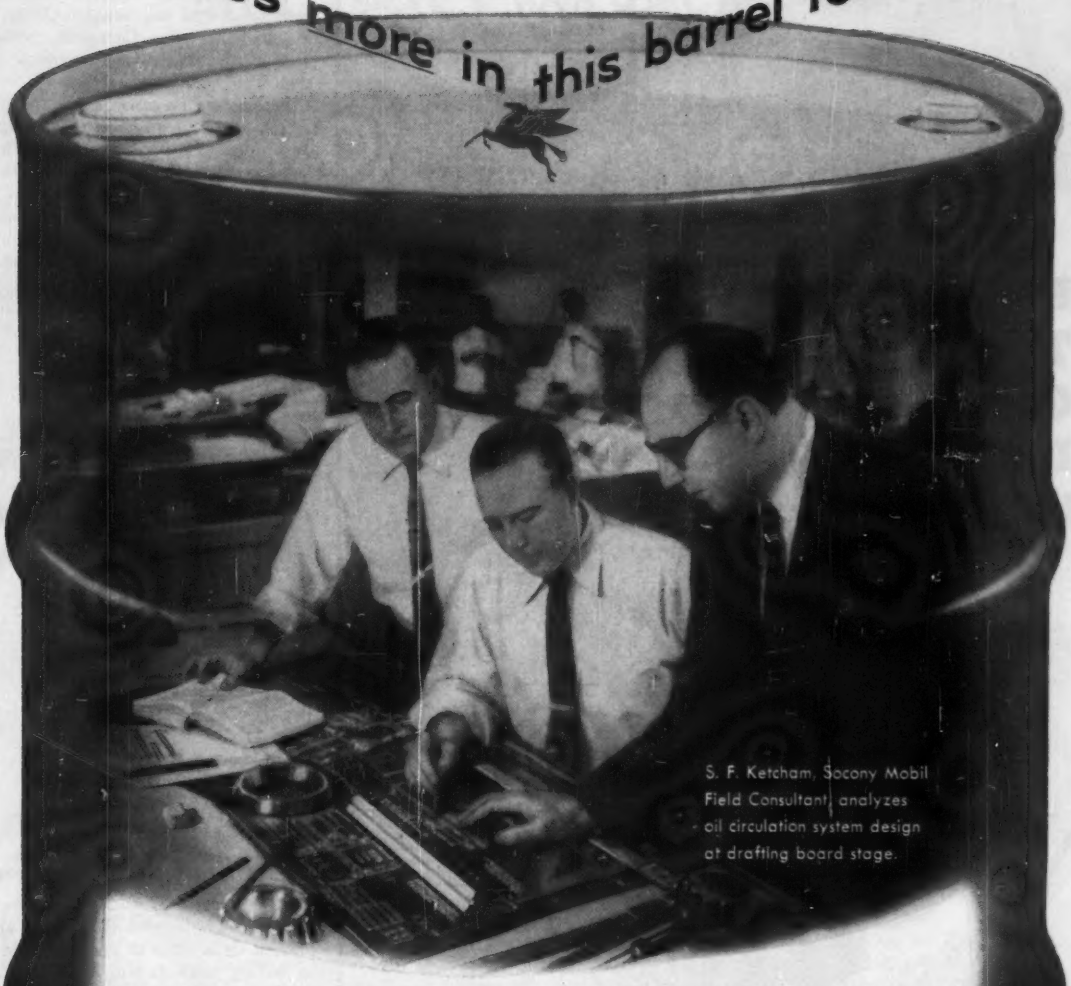


Condensate return pumps

1222 • Units are rated up to 10,000 sq ft of direct radiation with pressures up to 20 lb. High-pressure units are available up to 50 lb. Shallow type, cast iron receivers in 6 or 20 gal sizes permit low connection to return line. No foundation bolts are required. Pump can be set on floor or in shallow pit.

Pump has fully enclosed bronze impeller,

There's more in this barrel for you...



S. F. Ketcham, Socony Mobil Field Consultant, analyzes oil circulation system design at drafting board stage.

MORE MACHINE BUILDERS' APPROVALS
to help improve production and lower unit costs

Specify Socony Mobil—and you get petroleum products approved by more machine builders than those of any other oil company. And no wonder. Our engineers have always worked closely with designers and builders. They advise on hydraulic and lubrication system design . . . suggest *correct* products for each machine—to help improve your production, lower unit costs.

Socony Mobil products are also backed by *more* field engineers serving industry . . . *more* services for analyzing petroleum products in use . . . *more* on-the-job training of your personnel in correct product application . . . *more* continuous research to assure continually improved products . . . *more* practical experience—90 years!

* * *

Always specify Socony Mobil. There's *more* in every barrel for you!

SPECIFY SOCONY MOBIL — **FIRST STEP IN CUTTING COSTS**

SOCONY MOBIL OIL CO., INC., and Affiliates: MAGNOLIA PETROLEUM COMPANY
GENERAL PETROLEUM CORPORATION

LUBRICANTS • FUELS • CUTTING FLUIDS • WAXES • SOLVENTS • PLASTICIZERS • PETROCHEMICALS

"Lights Off"—
as simple
as this!

The
Peabody
Type SL
Gas-Electric
Ignitor...

... for fuel burners provides quick, positive and stable ignition for all firing conditions. The simple turning of one handle accomplishes the full operating sequence to establish the ignitor flame.

This ignitor does not employ long electrodes or insulators. All electrical components and adjustable elements are located *outside* the burner windbox; only the flame tube passes through it. All working parts are always readily accessible even when the ignitor is used with a pressurized furnace. This rugged packaged unit, of attractive modern design, is built of the finest materials to give long life with minimum maintenance.

It fills the needs for a dependable, positive and safe ignitor for all types of fuel burners, and is available for manual operation, as illustrated, or with motor drive for remote control. For detailed information, write direct or call your nearest Peabody representative.

PEABODY ENGINEERING CORPORATION

232 MADISON AVENUE, NEW YORK 16, N. Y.
OFFICES IN PRINCIPAL CITIES
PEABODY LIMITED • LONDON, S.W. 1, ENGLAND

6-240

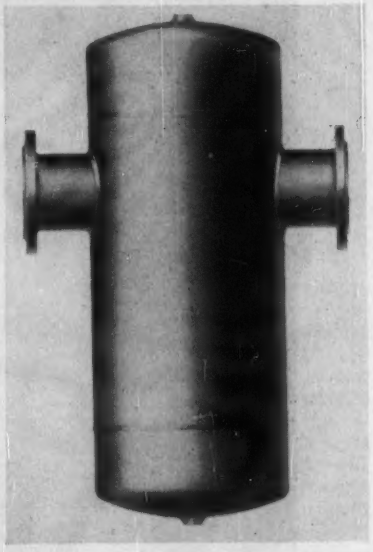
More EQUIPMENT NEWS

Begins on page 168

stainless steel shaft and compression type coupling. Will not vapor lock according to manufacturer. Capacitor motor has built-in thermatron and overload protection with automatic reset.

Automatic controls have double-pole switch mounted on receiver and operated by a float. No diaphragm or stuffing box. Duplex units are equipped with alternator float switch which operates pumps in sequence or together under peak loads.

The Deming Company,
42 Broadway, Salem, Ohio

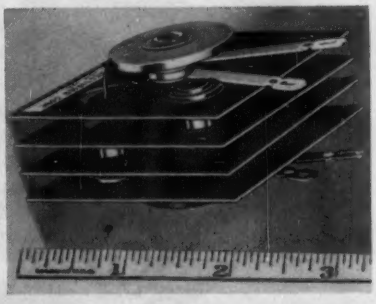


Steam, compressed air cleaner

1223 • Cleaner is said to separate moisture and entrainments until steam or compressed air is close to 100% dry and clean as testing methods can evaluate. Unit is multi-stage device which includes many stainless steel separating units in series. Manufacturer claims that it removes all line scale, mineral scale, rust, oil, dirt and liquid slugs. Three standard types are available for line diameters up to 12 in.

Bradshaw & Co, 311
Ross St, Pittsburgh, Pa.

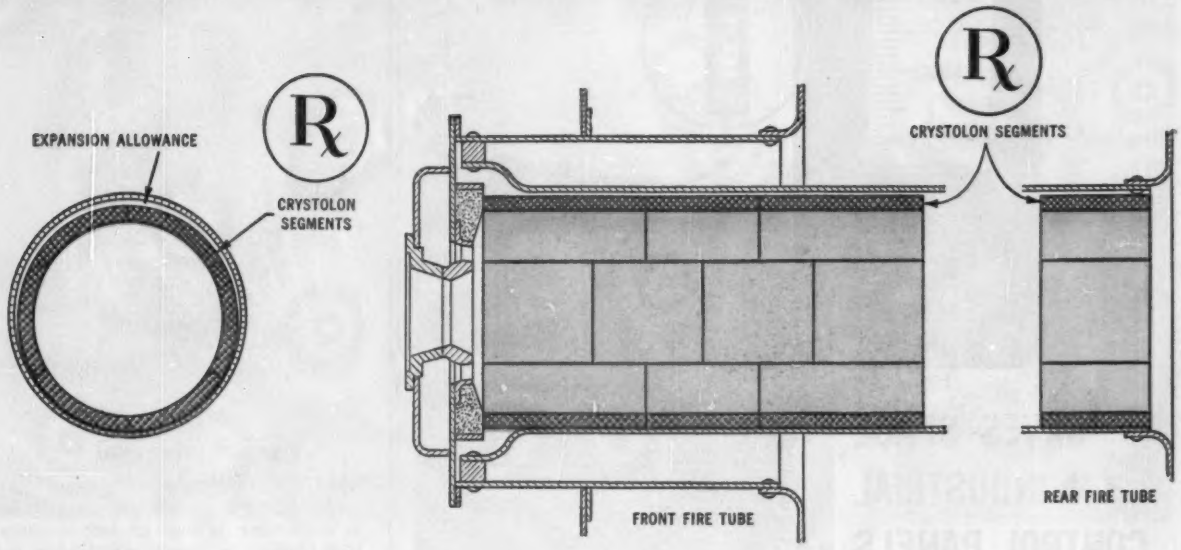
For more details on these items, use post cards p 177. Identify your request with item number.



Silicon rectifier stacks

1224 • 600-v silicon rectifier stacks are designed for power applications where

How CRYSTOLON* linings pay off in packaged boiler operations



In Fire Tube Packaged Boilers the swirling action of the flame causes particularly heavy erosive and abrasive attacks on the refractory lining. CRYSTOLON refractories, with their high resistance to abrasion and erosion, make the ideal lining material. Also, their ability to take up and release heat rapidly improves combustion and flame characteristics — a further advantage for over-all boiler efficiency.

In boilers of this type use arch brick for larger boilers, tongue-and-grooved segments for smaller boilers. In water wall packaged boilers use CRYSTOLON armor block at the grate level and CRYSTOLON brick and cement to protect the bridge wall,

Norton CRYSTOLON refractories, *engineered and prescribed* for better boiler operation, are characterized by exceptional hot strength, high refractoriness and thermal conductivity and great resistance to slag penetration, spalling and abrasion. Providing maximum protection against the mechanical and chemical attacks of a wide variety of fuels, they eliminate many costly repairs to grates and settings, as well as reducing down-time.

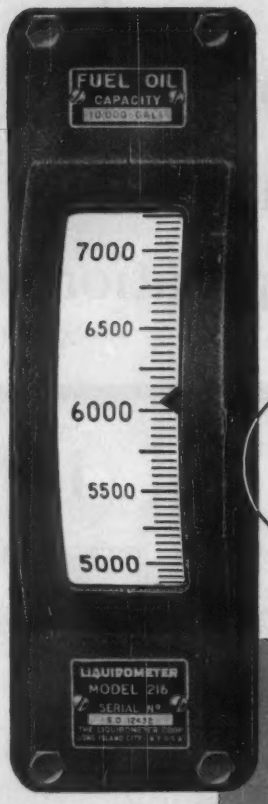
Send for booklet

describing how Norton refractories supply money-saving Rx's for your boiler applications. Write for your copy of *Refractories for Heat and Power* to NORTON COMPANY, 451 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto 5, Ontario.

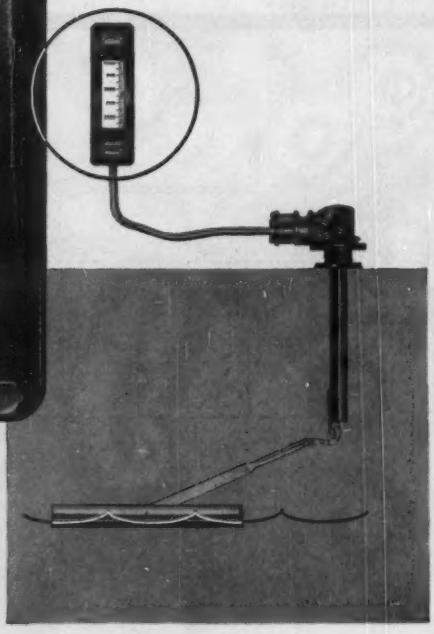
NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products... to make your products better

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries



NEW LIQUIDOMETER INDICATOR



SAVES SPACE ON INDUSTRIAL CONTROL PANELS

Twenty-inch dial in 3x10¼" case permits close readings

The new Liquidometer Model 216 Indicator gives the plant engineer a reliable, automatic reading of storage tank contents. Available in either vertical or horizontal design, the compact and highly readable Model 216 Indicator makes possible multiple installations on crowded control panels.

Teamed with Liquidometer's time-tested hydraulic transmission gaging system, the new indicator provides instantaneous remote indication of liquid levels—automatically. No outside power source is required. Virtually any liquid may be measured, and the indicator can be located up to 250 feet from the tank.

Engineered for dependability, the Liquidometer gaging systems highlight these design features:

- Maintenance free
- Integral temperature compensation
- Ease of installation—requires only one 2" diameter tank opening
- Safety—all gages Underwriters approved for hazardous liquids

For further details on the new Model 216 Indicator, write Dept. E for Bulletin 532.

LIQUIDOMETER INSTRUMENTS

THE LIQUIDOMETER CORP.
SKILLMAN AVENUE AT 36th STREET
LONG ISLAND CITY 1, NEW YORK

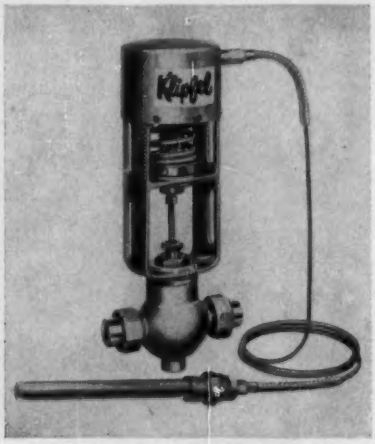
More EQUIPMENT NEWS

Begins on page 168

high ambient temperature, reliability, high efficiency and miniaturization are important, according to manufacturer.

Rectifiers are available in all circuit types with rms inverse voltage ratings of 70 v, 150 v, 140 v, 210 v, 280 v, 350 v, and 420 v, with dc output currents up to 4.5 amps at 75 C ambient temperature. Manufacturer states that it is possible to arrange stacks in series and parallel to increase voltage or current ratings.

International Rectifier Corp, 1523 E Grand Ave, El Segundo, Calif.

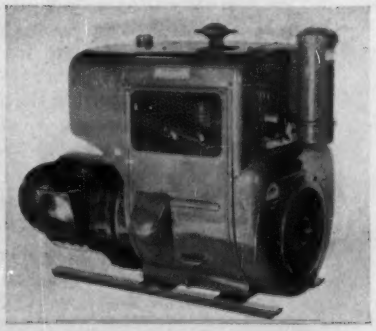


Temperature regulator

1225 • Vapor-pressure temperature regulator is suited for installations where danger of overheating, product spoilage or equipment damage is feared. Components are bellows actuator connected by capillary tubing to temperature sensitive bulb. Actuator is mounted on top of a yoke connected to valve. Bellows supplies power for controlling valve opening in response to temperature changes at bulb.

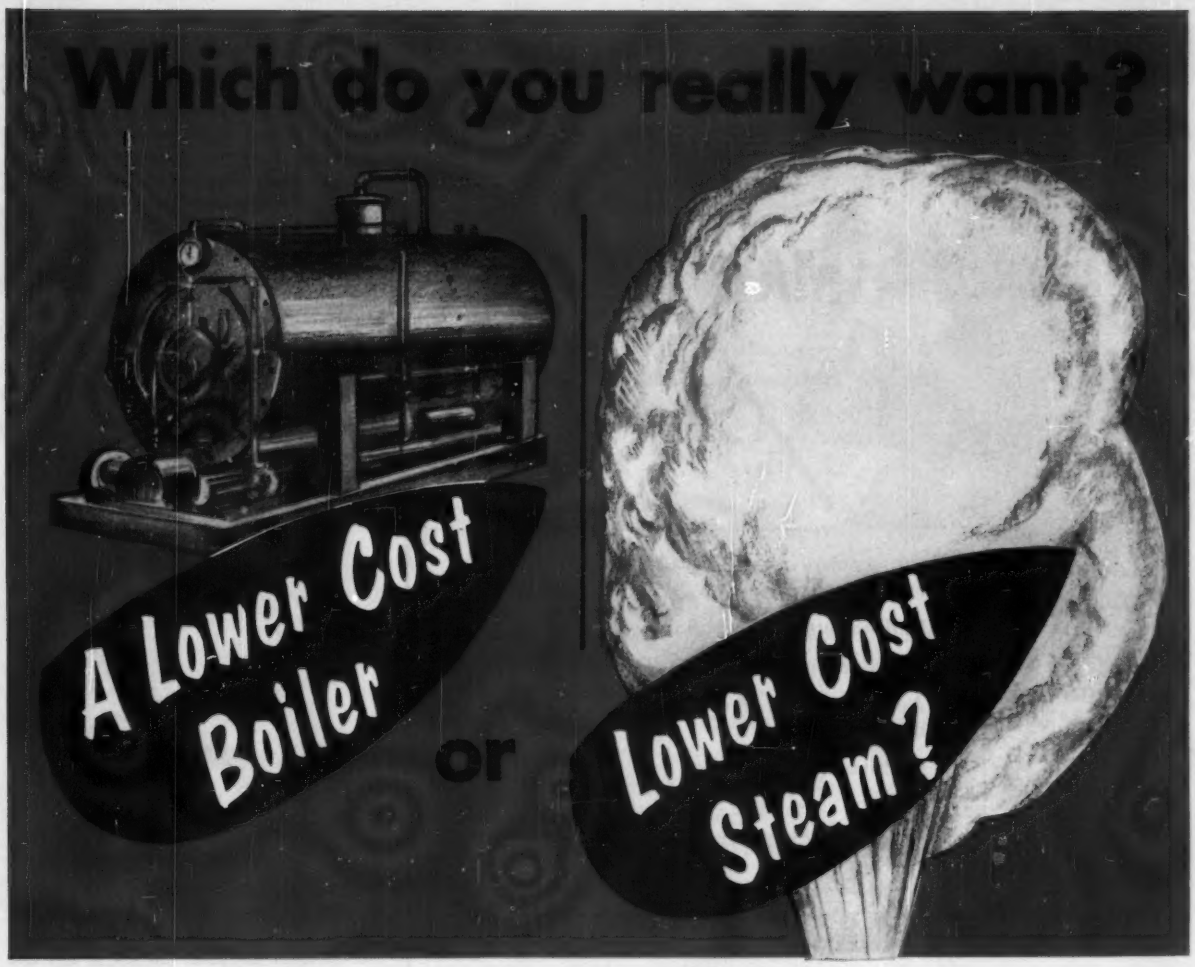
Klipfel Valves, Inc, 1077 Lincoln Ave, Hamilton, Ohio

For more details on these items, use post cards p 177. Identify your request with item number.



Engine-generator plants

1226 • Air- and water-cooled models are rated from 400 to 75,000 w. Three separate lines of diesel electric plants range from 10,000 to 300,000 w. Both portable



A word about price vs. cost

When you come right down to it, a boiler is only as "cheap" as the results it gives you! A low-cost boiler that's unreliable or incomplete is the most expensive one on the market.

That's why we've always built AMESTEAM GENERATORS up to a standard, not down to a price. Throughout our 108 years of building boilers, this policy has paid off in lower-cost steam for Ames customers. It is no coincidence that so many firms specify "AMESTEAM" on the strength of its reputation for reliability and economy of operation. Ames customers are invariably "repeat" customers! They know that lower-cost STEAM rather than a lower-cost boiler is the best buy.

AMESTEAM GENERATOR

20 sizes, 10 to 600 h.p. 15 to 200# Oil, Gas or Oil-Gas Combination.

AMES IRON WORKS INC.
BOX H-126 OSWEGO, N. Y.

MAIL COUPON TODAY

AMES IRON WORKS
BOX H-126, OSWEGO, N. Y.

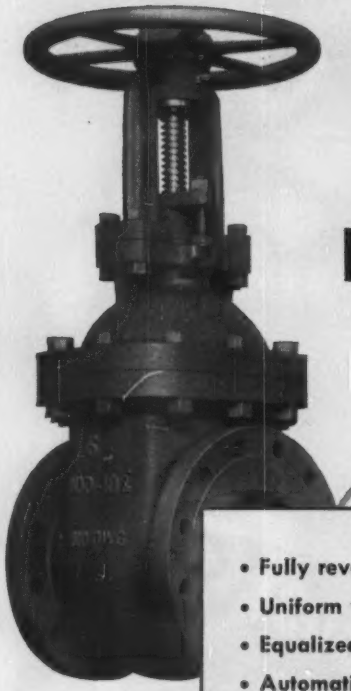
Gentlemen:

Please send me further information on AMESTEAM GENERATORS and name of the nearest representative.

NAME.....

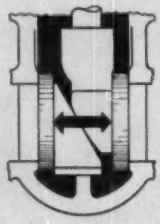
COMPANY.....

ADDRESS.....



LESS MAINTENANCE

- Fully revolving discs
- Uniform wear distribution
- Equalized wedging pressure
- Automatic adjustment for body distortion
- Positive closing



. . . with Darling gate valves on the job!

DARLING *fully revolving double disc parallel seat* gate valves don't need maintenance as often as other valves.

This exclusive Darling design eliminates valve leakage and faulty operation . . . due to body distortion and man-handling. You can always count on Darlings to close easier, to close tight, and to serve longer without attention.

Available in iron body, cast steel, iron body rubber lined, all bronze and special alloys . . . for all kinds of ordinary and special services.

Made with the kind of ends needed for your particular installations. Write for complete information.

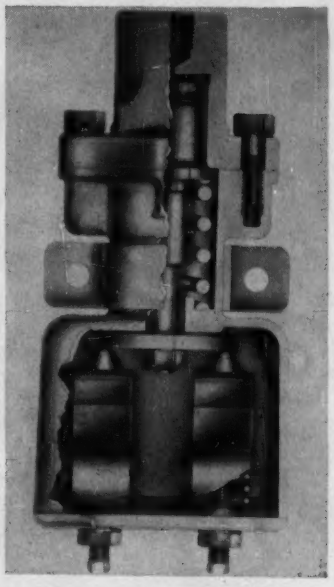
DARLING VALVE & MANUFACTURING CO.
Williamsport 8, Pa.
Manufactured in Canada by
Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

More EQUIPMENT NEWS

Begins on page 168

electric plants and non-diesel plants have automatic and semi-automatic control apparatus for special applications. Desired control configurations may be specified.

Gen-A-Matic Corp, 14741 Bessemer St, Van Nuys, Calif.



Piston pressure switch

1227 • Pressure switch, *Model 9622* or *C9622*, is capable of sensing two different pressures in one system and actuating independent electrical circuits at any two desired points, according to manufacturer. Unit may be used to maintain pressure where it is imperative that system pressure does not exceed or fall below predetermined values. Unit accurately senses any system pressure over an adjustable range of 15 to 3000 psi for proof pressures from 3000 to 7000 psi, depending on the switch setting. Switch incorporates two UL-approved spot-snap-action switching elements rated for ac and dc circuits. Each switching element is electrically independent of the other.

Pressure settings are made by two external adjustment screws which can be locked in place to avoid accidental disturbance. Switch comes with adaptable mounting bracket.

Model C9622 has two calibrated dials for visual setting, without gages, before or after installation on a pressure line.

Barksdale Valves, 5125 Alcoa Ave, Los Angeles 58, Calif.

For more details on these items, use post cards p 177. Identify your request with item number.

Firefighting system

1228 • Dry chemical for extinguishing system for flammable liquid, electrical and textile fire hazards can be operated manually or automatically. Consists of 30-lb capacity dry chemical unit installed near hazard and serving as storage tank for dry

COOLING TOWER POWER
is most efficiently utilized by
Marley Multi-Blade Cast Fans

Marley fans are unexcelled for the job of converting applied power to actual cooling performance, but the qualities that make them positively distinctive are ultra-smooth operation and long-life durability. It requires just two words—MULTI-BLADE and CAST—to point out the characteristics that produce these stand-out advantages.

Watch a 22-foot, 12-blade Marley fan operate; listen to it operate. The customary "huff and puff" pulsation of large fans is not there. There is no structure-shaking vibration. The result? Longer life for speed reducer, drive shaft, fan cylinder and structure. That is the multi-blade advantage.

The Marley fan is inherently rugged and durable. Each blade is a single casting, a rigid, homogeneous unit of specially selected aluminum alloy that retains its aerfoil shape permanently. Marley fans never develop tip-sag or service flutter. The design completely eliminates weld and rivet failures, skin cracks, imperfect laminations and internal corrosion.

All machine operations on Marley blades and hubs are carefully quality-controlled. Blade surfaces are protected by a double-coated baked plastic finish. Each fan is balanced at the factory and match-marked for field assembly.

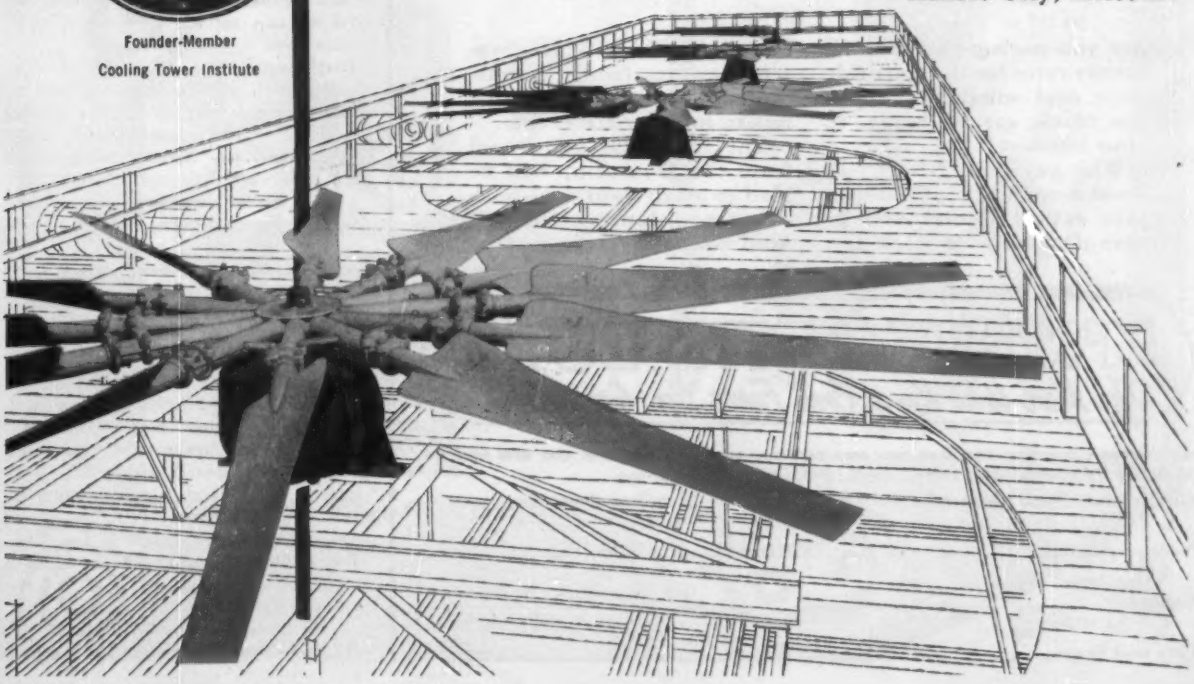
Owners of towers of all types and makes are modernizing their equipment by changing to Marley Multi-Blade Aerfoil Fans—often after side-by-side comparative test with present equipment. Write for Bulletin FH356 and get the complete story of modern design applied to cooling tower fans.

MARLEY

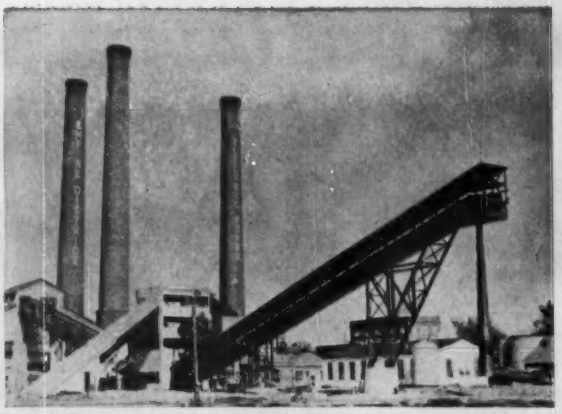
Founder-Member
Cooling Tower Institute

The Marley Company

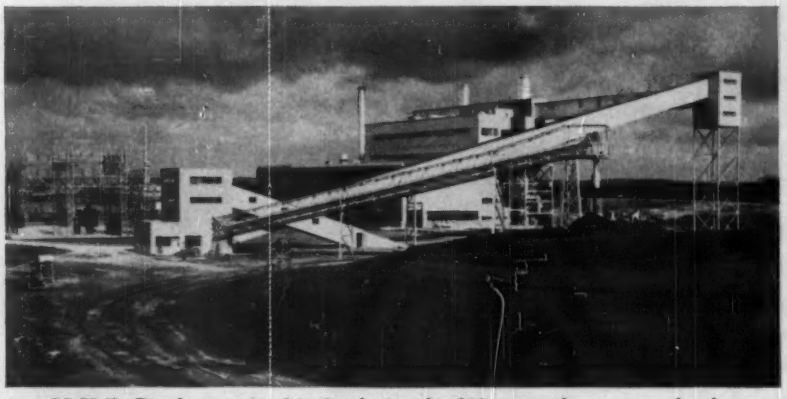
Kansas City, Missouri



EARN EXTRA PROFITS IN SAVINGS



McNally Pittsburg developed this 250 ton per hour system for the EMPIRE DISTRICT POWER & LIGHT CO.



McNally Pittsburg assisted in developing this 300 ton per hour system for the KANSAS POWER & LIGHT CO.

—With Cost-Cutting

COAL-HANDLING SYSTEMS

Engineered for Your Plant

Are you paying "extra fare" luxury rates for that last ride your coal must take from the truck, car, or barge, to your bunkers?

Why pay more? Why risk breakdowns, when you can *save* extra "profits" and be sure of year-round efficiency.

McNALLY PITTSBURG Systems automatically handle more coal per dollar—minimum maintenance costs.

The men who know coal from the ground up will be glad to study your coal-handling problems with you. Mail coupon.

McNALLY PITTSBURG

"The Men Who Know Coal From The Ground-Up"

McNally Pittsburg Mfg. Corp., Dept. PO, Pittsburg, Kansas
Gentlemen: Send more information on your Coal-Handling Systems.

Name_____ Title_____

Company_____

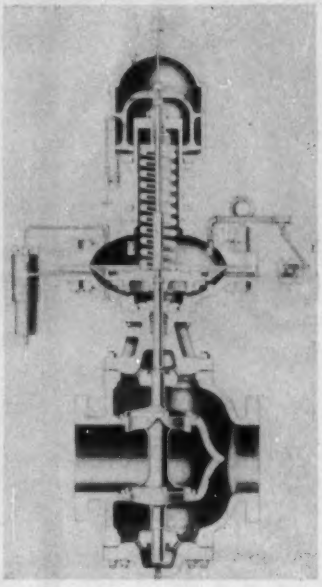
City and State_____

More EQUIPMENT NEWS

Begins on page 168

chemical. CO_2 gas pressure cartridge furnishes pressure to expel dry chemical onto fire through piping connecting dry chemical unit with hazard area. System can provide total flooding or local application. Accessory equipment is available.

Ansul Chemical Co, 101 Stanton St, Marinette, Wis.



High-pressure regulator

1229 • Manufacturer claims that this regulator solves the problem of vertical instability or "jumping" that is sometimes encountered on high-pressure gas-transmission lines. Featured in the *Series 883* and *885* regulators is an oil dash-pot which is said to dampen out any tendency of valve to jump, yet will not cause valve to deviate from control point.

Diaphragm casings are capable of withstanding 1000 psi. Steel loading pilot is suitable for pressures up to 1000 psi and has an adjustable reduced-pressure range of 100 to 450 psi. Series is available in valve body sizes 2 through 12 in.

Fisher Governor Co, Marshalltown, Iowa

For more details on these items, use post cards p 177. Identify your request with item number.

Automatic gas valves

1230 • Fast closing and slow opening are said to be features of *Series 81L* gas valves. Motor-operated valves have compression type spring that automatically shuts off fuel in 0.8 of a second. Heavy duty electric drive unit controls rate of opening to reach 75% of maximum fuel flow in six seconds. Available in sizes from 1 to 6 in.

For additional information use Reader Service post cards on page 177 or send request direct to the manufacturer.

Electronics Corp of America, 77 Broadway, Cambridge 42, Mass.

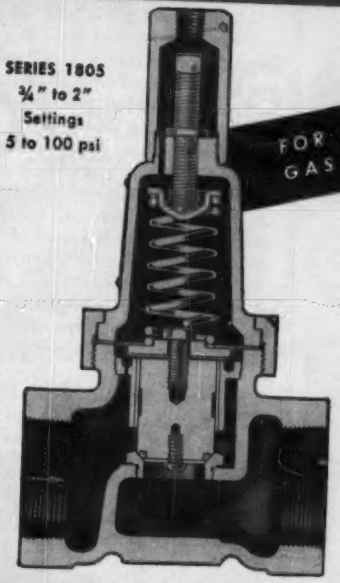
look to FISHER

for genuine relief from overpressure worries!

Hundreds of plants have found Fisher compact and self-contained relief valves the answer to their relief or back pressure control problems. Whether it may be a rather unusual problem, or simply to protect your gas system for safety reasons, or possibly to relieve excess pressure from a pump by-passing back to suction, the chances are Fisher could solve your problem. May we suggest you contact our representative in your area?

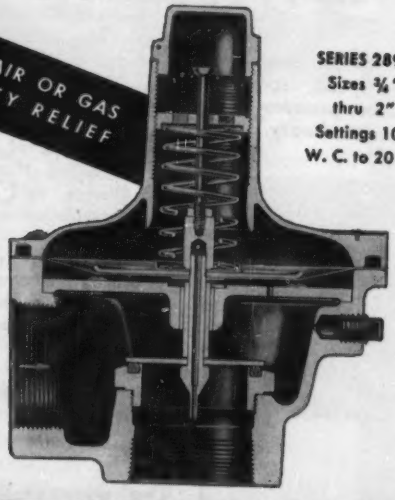
SERIES 1805
¾" to 2"
Settings
5 to 100 psi

FOR AIR OR GAS RELIEF



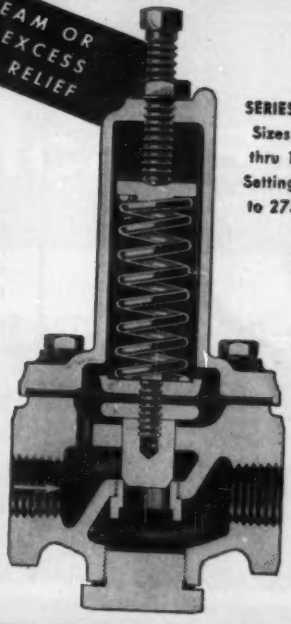
FOR AIR OR GAS SAFETY RELIEF

SERIES 289H
Sizes ¾"
thru 2"
Settings 10"
W. C. to 20 psi



FOR STEAM OR LIQUID EXCESS PRESSURE RELIEF

SERIES 372
Sizes ½"
thru 1½"
Settings 10
to 275 psi



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MARSHALLTOWN, IOWA • WOODSTOCK, ONTARIO
LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

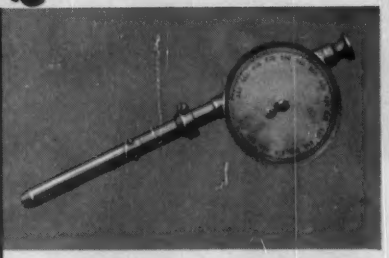
FISHER
Since 1880

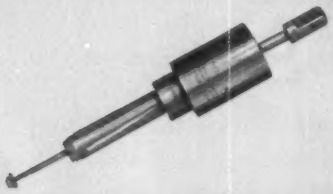
For better small tube maintenance

ELLIOTT TUBE CLEANERS and EXPANDERS

ELLIOTT TUBE GAGE

Measures inside tube diameters in .001". A quick, guide for setting tube expanders for condenser and heat exchanger tubes. Three point contact of hardened steel balls insures accurate measurements.



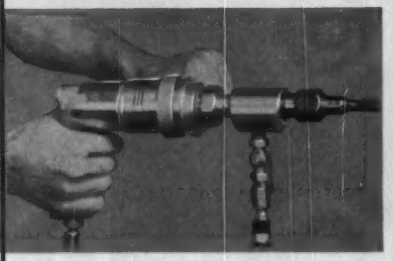


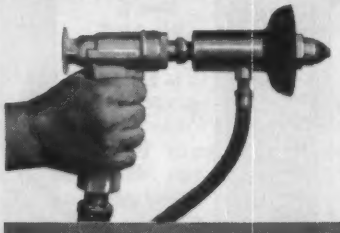
ELLIOTT TUBE EXPANDERS

Roll condenser and heat exchanger tubes quickly and accurately. Rotating, parallel self-feeding rolls insure good joints. For tubes ½ in. through 1½ in., 16 gage.

NEW ELLIOTT 5100 SERIES HEAT EXCHANGER TUBE CLEANER

Powerful air-driven motor with non-rotating, water feeding attachment, trigger-action for motor control, finger-action valve for water flow. Built-in speed governor eliminates shaft-whip. Choice of two sizes.



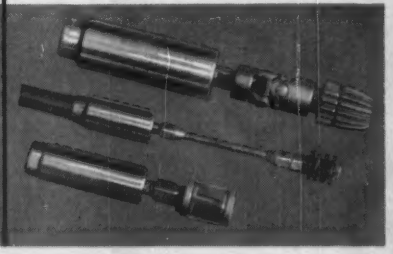


ELLIOTT JIFFY GUN WITH BOOSTER

Combines water and air pressure for extra power and speed, recommended where water pressure is low, or scale deposit is heavy.

ELLIOTT 600 Series Cleaners

For straight and curved small tubes. Air or steam driven motors. Can be equipped with expanding brushes and scraper heads.



YB-10

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Address Elliott Company, Lagonda Division, Springfield, Ohio

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BOOKSHELF

Industrial Electricity. Vol I. Direct Currents. *3rd edition. By Chester L Dawes, Associate Professor, Emeritus, of Electrical Engineering, Harvard University. 431 pp, illust, $5.50. McGraw-Hill Book Company Inc, 330 West 42nd St, New York 36, N. Y.*

The third edition of Volume I of Professor Dawes' well-known book brings the text and illustrations up-to-date, in line with the rapid developments of the last few years in industrial electricity. This edition, following the original plan, is designed as a text for technical institutes and some technical high school courses. It may also be used for self study. Electrical engineering is developed in simple language with simple formulas. Typical industrial electrical problems are included.

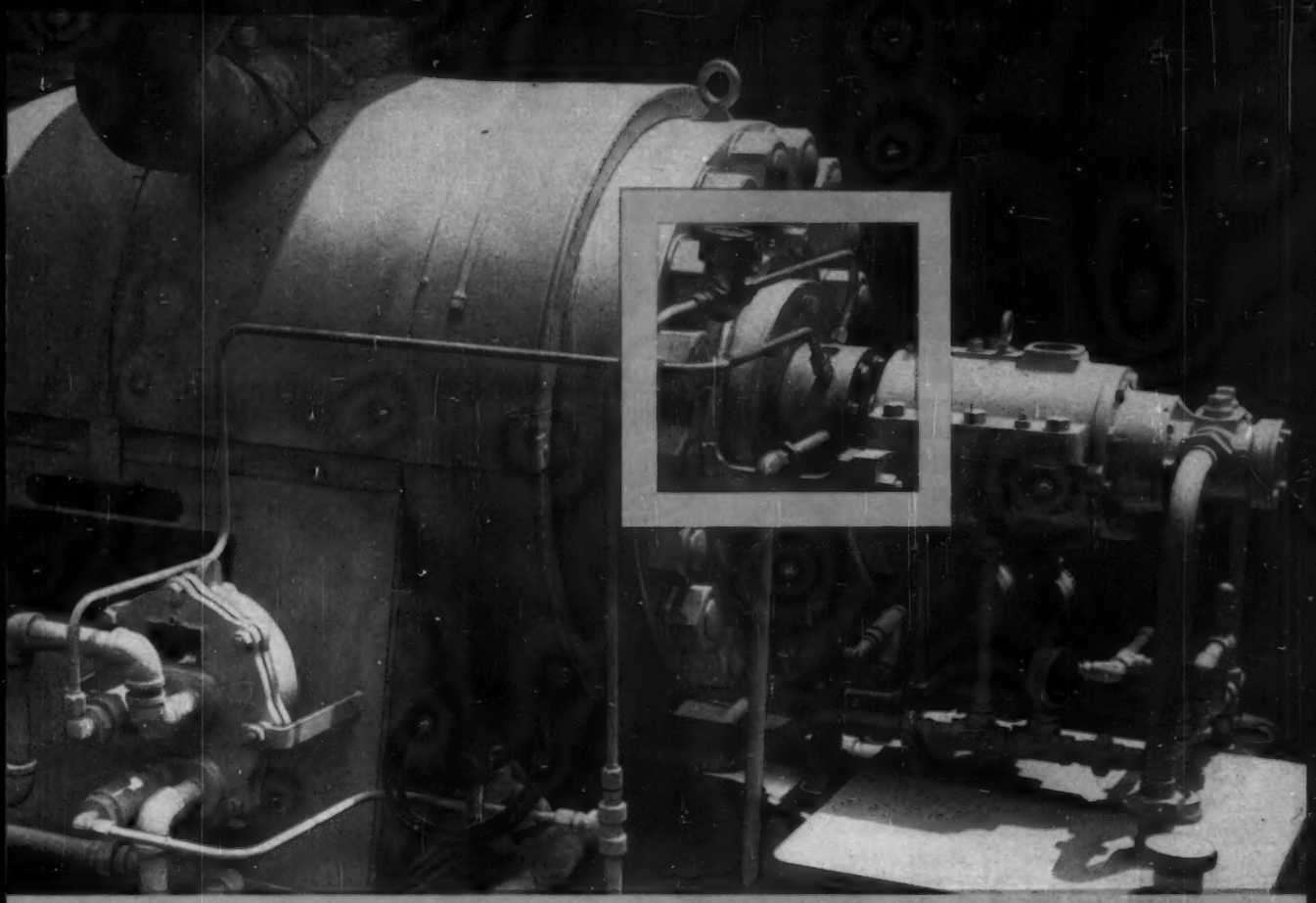
The following additions are included in this third edition: more advanced applications of Kirchoff's laws and superposition theorem; new types of batteries, expansion of magnetic theory and a discussion of magnetic materials; more detailed treatment of motors and generators, particularly armature reaction and commutation; extension of the electrostatic theory and capacitance calculations, and a discussion of the amplidyne as a voltage regulator.

Electronics in Industry. *By George M Chute, Professor of Electrical Engineering, University of Detroit. Second edition. 431 pp, illust, $7.50. McGraw-Hill Book Company, Inc, 330 W 42nd St, New York 36, N. Y.*

Intended primarily for engineers in industry, this book concentrates on explanation of electronic devices and their use in practical circuits. The subject is presented in terms of equipment already designed and obtainable, with some fundamental theory to back it up. No previous knowledge of electron tubes is assumed. Occasional statements are not technically precise. The author felt that their correction would only confuse the average reader.

A wide variety of applications are covered, including time-delay relays, rectifiers, filtering, welding, dc motor control, voltage, regulation, heating and light dimming controls, temperature recorders, high speed light relays, servo systems and instruments. Numerous circuits relating to specific processes are discussed. There is a chapter on devices that are generally associated with electronics but which do not include electron tubes, such as semiconductors and magnetic amplifiers.

Two companies, American Gas and Electric Co and Commonwealth Edison Co, have revealed plans for an extra-high-voltage transmission tie line between their two electric power systems. It is estimated that the line and related facilities in Indiana and Illinois will cost close to $25 million.



City of Pasadena realizes

Big Savings on Boiler Feed with BJ Mechanical Seals

The City of Pasadena Light and Power Department has been using BJ Mechanical Seals in high temperature, high pressure boiler feed service for more than a year. These seals are installed on three double case boiler feed pumps with suction pressures to 400 psi, temperatures of 427° F. and an operating speed of 3550 rpm. The seals incorporate a pumping ring and small Graham Heliflow heat exchanger. Here are the results:

1. **SAVINGS ON MAINTENANCE**—Stuffingbox maintenance has been completely eliminated since installation of the seals. There has been no repacking labor cost... no pump shut-down loss.

2. **SAVINGS OF TREATED FEED WATER**—Previous to BJ Mechanical Seal installation, considerable loss of expensive, prepared feed water occurred. Now leakage loss is imperceptible.

3. **SAVINGS OF HEAT**—BTU's formerly lost through stuffingbox leakage are now sealed in for greater overall boiler feed operating efficiencies.

YOU CAN ACTUALLY COUNT THE SAVINGS IN LOWER COST OF KILOWATTS!

If you are operating high temperature, high pressure boiler feed pumps it will pay you to investigate now the big savings available from BJ Mechanical Seal installation.

Contact your BJ Pump Sales Engineer or write:

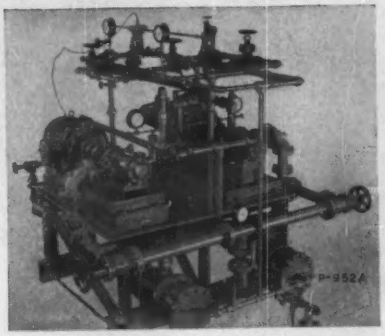
BYRON JACKSON PUMPS
INCORPORATED

A subsidiary of Borg-Warner Corporation
P.O. Box 2017A, Terminal Annex • Los Angeles 54, California

NATIONAL AIROIL

SERVING INDUSTRY'S COMBUSTION REQUIREMENTS FOR 43 YEARS

NATIONAL AIROIL FUEL OIL PUMPING and HEATING UNITS



P-952A—Steam Turbine and Electric Motor drive gives flexibility in this compact Model P-ES2H size No. 25 unit.

Complete range of sizes and models in both medium and high pressure types . . . *more compact than ever!* Write for Bulletin 40.

NATIONAL AIROIL COMBUSTION ACCESSORIES

AIR CONTROL DOOR and FRAME

FUEL-OIL SUCTION STRAINER

WIDE VIEW PEEPHOLE

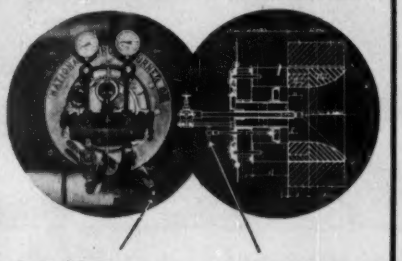
IGNITION PORT

FURNACE RELIEF and ACCESS DOOR

FUEL-OIL HEATER

These and other "accessory items" for every industrial liquid fuel-gas installation. Ask for Brochure No. 10.

NATIONAL AIROIL UNIVERSAL REGISTERS with TYPE "SA" OIL BURNERS



Control for Air Vane

Control for Refractory Faced Disk

BETTER PERFORMANCE with NATIONAL AIROIL Universal Registers because they have a DUAL FEATURE for controlling air volume independent of turbulence. Air vanes can be instantly reversed to change direction of turbulence while air volume is separately regulated by a refractory faced disc control. Both adjustments can be made while the burner is firing.

Another "dual advantage" of NATIONAL AIROIL Universal Registers is that they are equipped for dual fuel firing of gas and oil. Universal Registers with burners are available in three (3) sizes . . . capacities up to 60,000 lbs. of steam produced per burner per hour. Write for Bulletin 51.

OIL BURNERS and GAS BURNERS for industrial power, process and heating purposes
STEAM ATOMIZING OIL BURNERS
SLUDGE BURNERS, Steam Atomizing
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DUAL STAGE, Combining Steam and Mechanical Atomization
LOW AIR PRESSURE OIL BURNERS
AUTOMATIC OIL BURNERS, for small process furnaces and heating plants
GAS BURNERS
COMBINATION GAS & OIL BURNERS
FUEL OIL PUMPING and HEATING UNITS
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INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

COMBUSTION

Continued from page 123

operation in the stable flame area.

With gases that aren't all methane but have a fair amount of propane, the blowoff curve will shift upward and the flashback curve will peak higher and spread at the bottom. Amounts of carbon monoxide and hydrogen will cause larger shifts. Flashback area increases considerably in the lower ranges and the blowoff curve rises more steeply because the flame speed is much higher at any given point than methane's. Added amounts of inert gases, such as nitrogen or carbon dioxide, make both flashback and blowoff curves drop. But the effect of the inerts isn't too pronounced unless there is more than 5 to 7% by volume of them.

Before we discuss combustion efficiencies, let's go back for a minute to the basis for all energy calculations in physics—the conservation of energy principle. In any heat process, all heat put in must come out somewhere. Heat balance is just what happens to heat input to a boiler and accounts for all heat put into the unit.

Fuel input doesn't contain much heat in itself, but it's capable of releasing heat through chemical change. The change, called combustion, releases heat to the gases which are products of that combustion. The gases then transfer heat to the boiler surfaces. To do this there must be enough temperature differential between the gases and the boiler surfaces.

Stack gases can't be colder than the steam being produced or, obviously, the steam would heat the gases and part of the steam output would be lost. Generally accepted rule is that the gas temperature should be 100 to 150 F above steam temperature to get the best heat transfer. Stack loss, then, is the amount of heat still in the gases after we've transferred all we can so far as the boiler is concerned.

Combustion efficiency, by definition, is 100%—stack loss × 100 ÷ input. Figs. 2 and 3, p 123, are typical efficiency charts, based entirely on properties of the gases used. The only effect of the boiler-burner combination is what the final conditions of the stack gases will be. The steam working pressure largely determines stack temperature and the CO_2 reading is based on the amount of excess air. We know it's necessary to have some excess air to insure complete combustion if there is any change in the blower or the gas supply.

Stack temperature and the amount of stack gases determine combustion

(*Continued on page* 198)

TUBE-TURN

In small piping too you get big savings by welding

Five years ago, the generally accepted practice among engineers and contractors was to weld non-critical pipe larger than 2-inches and thread the smaller sizes. Today, that dividing line has gone down; much piping as small as ½-inch is now being welded. In small piping as in large, the big reason for welding is *to save money* . . . in installation cost, in material cost, in maintenance cost. See next page for typical results. For the small pipe jobs, too, you get the *most for your money* when you specify and buy TUBE-TURN* Welding Fittings and Flanges. Your nearby Tube Turns' Distributor can give you speedy service in sizes from ½-inch to 42 inches!

The Leading Manufacturer of Welding Fittings and Flanges

TUBE TURNS LOUISVILLE 1, KENTUCKY

A Division of National Cylinder Gas Company

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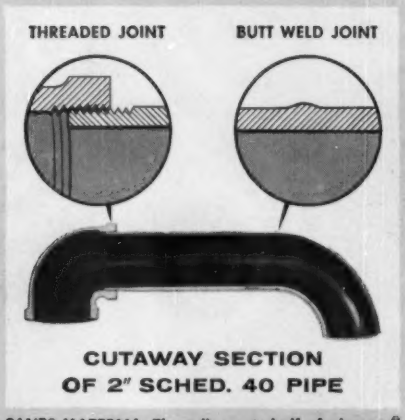
*"TUBE-TURN" and "tt" Reg. U.S. Pat. Off.

WHY IT PAYS...

SMALL DIAMETER PIPING... *why it pays to specify welded construction with* TUBE-TURN *Fittings*

NEVER LEAKS. Welded joints are permanently as strong and leakproof as the pipe itself. Photo shows welded lube oil lines for one of four diesel engines, replacing threaded lines which leaked. If welded in first place, would have saved $4000 replacement cost. Pipe is 2½" with TUBE-TURN Fittings.

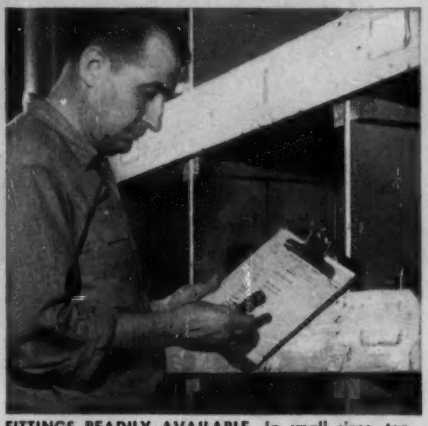


SAVES MATERIAL. Threading cuts half of pipe wall away as shown. The welded joint is as strong as the pipe. An installation of Schedule 40 pipe, welded, is stronger than Schedule 80 threaded. Hence, for equal strength welded piping can cut material costs 30-50%.

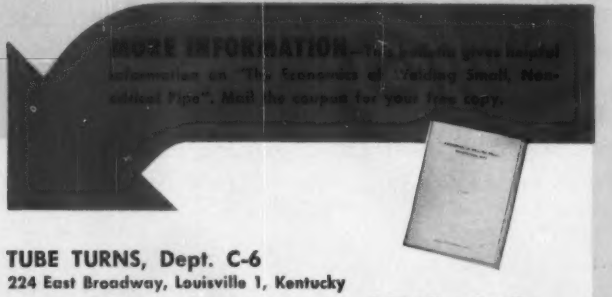
TAKES LESS TIME to weld than to thread pipe above 2" and about equal time for smaller sizes, according to recent tests on hundreds of joints made by many different pipe fitters. Welded joints in 1½" piping such as the school heating line shown, averaged 7 minutes compared to 8 minutes for threading and tightening fitting.

IS COMPACT, NEAT. This installation of 1½" and 2" boiler blow-off piping shows ability to nest welded lines close together for better layout and streamlined appearance. Also, insulation, where needed, is easier to apply.

TOOLS ARE SIMPLE. Small, inexpensive welding outfits can cut, weld, heat to bend, solder or braze. They are easy to haul to job and simple to use. All pipe for this factory radiant heating system was fabricated on the site.



FITTINGS READILY AVAILABLE. In small sizes, too, your Tube Turns Distributor is stocked to give you prompt, efficient service. Call him on *all* your needs in welding fittings and flanges . . . from ½" to 42".



TUBE TURNS, Dept. C-6
224 East Broadway, Louisville 1, Kentucky

Please send free copy of "Economics of Welding Small, Noncritical Pipe".

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Company Address _____

City _____ *Zone* ____ *State* _____

Your Name _____

Position _____

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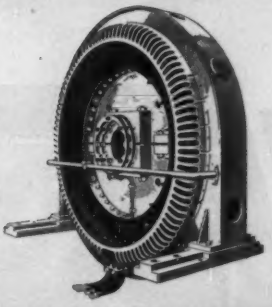


HOW GENERAL ELECTRIC SYNCHRONOUS MOTORS REDUCE MAINTENANCE COSTS

AFTER WINDING OPERATION, NEW POLYEX COILS WILL BE VARNISHED TO SEAL OUT MOISTURE AND CORROSIVE OR ABRASIVE MATERIALS

New Polyex* coils increase motor life

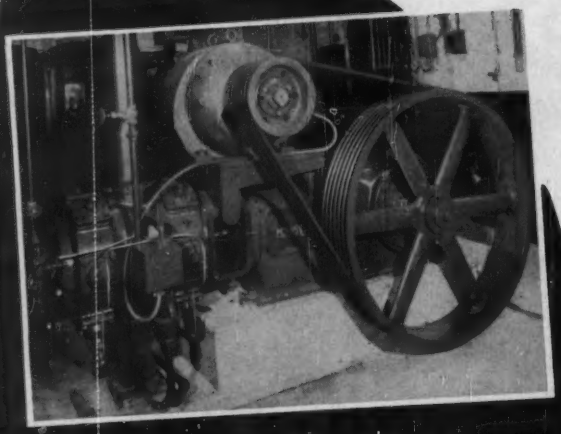
Polyex insulated coils, a recent General Electric development, will greatly increase the life expectancy of large motors and substantially reduce maintenance requirements. Prior to being introduced into the manufacture of G-E motors, Polyex coils were subjected to numerous exacting tests to prove insulation characteristics. These tests showed that Polyex coils have many times the physical strength of conventional coils. Throughout the tests Polyex insulation retained its superior characteristics—even after being baked for thousands of hours at 125 C.

Twice the resistance of other coils to operating temperature changes, moisture, contamination and mechanical damage is possible because Polyex coils are insulated with polyester films and fibres which are treated with the newest hydrocarbon resins. This all-dielectric insulating system is possible because the latest technological developments of chemistry and engineering are combined with the practical skills of more than a half century of coil manufacture.

Polyex insulated coils are but the most recent development in General Electric's continuing efforts to provide a maximum in motor life and reduce motor maintenance to a minimum. For more information about General Electric motors, contact your Apparatus Sales Office. A sales engineer will be glad to explain the many other advantages of G-E low-speed synchronous motors. Write for Bulletin GEA-5332. Address Section 775-6, General Electric Company, Schenectady 5, New York.

*Reg. Trade-mark of General Electric Co.

GENERAL ELECTRIC



You Get *RELIABLE*
COMPRESSOR
PERFORMANCE

with
Pennsylvania
AIR CUSHION VALVES

Pennsylvania compressors are designed to earn and keep your confidence by providing quiet, efficient service even under the most exacting conditions — and with low maintenance cost. Actual valve efficiency improves with use.

The AIR CUSHION valve is tight seating and constructed entirely without bolts — without nuts or screws that might work loose or burn fast; one reason why Pennsylvania compressors give many years of dependable performance.

All Pennsylvania compressors have an extra rugged, dust and oil tight main frame that is completely weatherproof. Solid ends connecting rod, wedge adjusted crank pin and crosshead pin bearing, marine type crosshead with shim adjusted shoes and force feed cylinder lubrication, assure performance-proved compressors adaptable to most applications.

Write for Bulletin A-201.

PENNSYLVANIA PUMP & COMPRESSOR COMPANY

Main Office & Works, Easton, Pennsylvania

HAE-PP325-856 **EARNING CONFIDENCE SINCE 1920.**

PENNSYLVANIA
PUMP AND COMPRESSOR COMPANY

COMBUSTION

Continued from page 194

efficiency. Amount of stack gases can be determined by CO_2 reading and firing rate. Charts show what happens to the combustion efficiency for each factor. With a high CO_2 (indicating either low excess air or low total amount of stack gases) stack loss is lower than with a low CO_2. As stack temperature rises, combustion efficiency drops. So it's important to get the lowest stack temperature and the highest possible CO_2 to reduce the losses.

The picture isn't complete without considering other heat losses, though these can't be charges against combustion efficiency. Moisture in the air, getting a free ride and absorbing heat along with the products of combustion, adds to stack losses. With a relative humidity of 40% at 60 F the loss is between ¼ and 1% at different stack temperatures.

Another loss is due to radiation from the boiler surfaces to the surrounding atmosphere. Insulation may make the loss small but it must be considered. Finally we have the 'unaccounted-for loss.' As the term implies, the loss can't be assigned to any specific cause, but it can't be ignored.

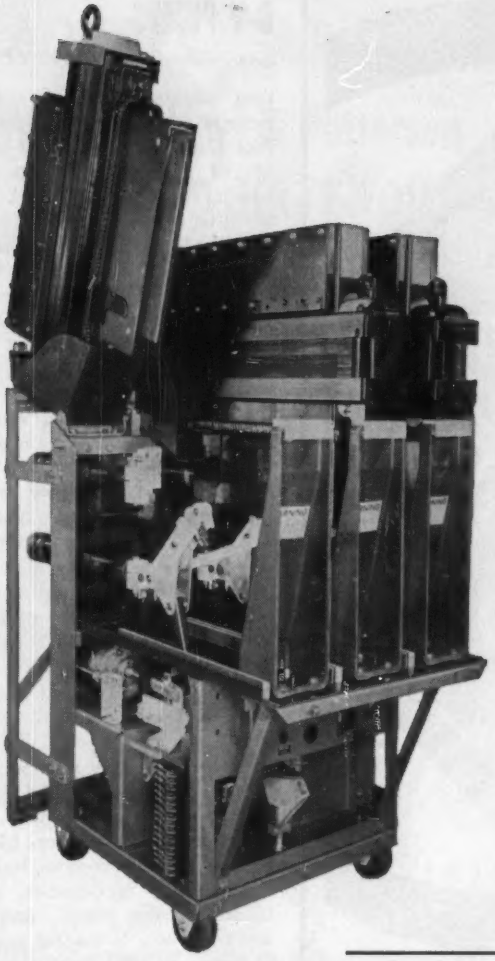
Added up, moisture, radiation and unaccounted-for losses generally eat up from 1 to 3% of total input. These are in addition to stack loss and must be included when calculating overall thermal efficiency. So we know, for instance, that if our combustion efficiency is 81%, overall thermal efficiency will be from 1 to 3% less and we'll have to reach a combustion efficiency of at least 83% if we want to maintain an 80% output.

C-V PUMPS

Continued from page 129

work. Here, a few items deserve mention. After the pump has been running for several hours, it's a good idea to thoroughly relubricate it, check packing adjustment and motor temperature. As we said, gear-reducer and motor-operating temperatures run rather high, particularly with fractional-horsepower pumps. Smaller totally-enclosed motors have a rated temperature rise of 55 C above room temperature. In a hot area, such as a boiler room, total temperature may run 185 to 190 F. This is normal for these motors and creates no hazard provided electrical overload device is correct for motor current.

Assuming that installation and start-up was according to Hoyle, maintenance shouldn't mean anything more



A Complete Line of I-T-E Metal-Clad Circuit Breakers for Every Application

Anticipating the proposed addition of three new higher metal-clad switchgear ratings, I-T-E now has a complete line of circuit breakers which are fully developed and tested to meet every requirement.

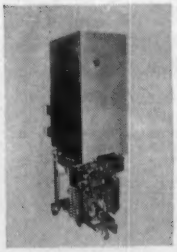
New 75 mva interrupting rating for I-T-E metal-clad switchgear applied on 4.16 kv systems

New 350 mva interrupting rating with a new 3000 amp continuous rating for application on 2.3 or 4.16 kv systems

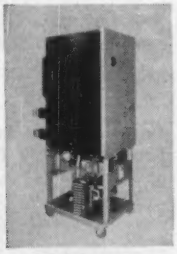
New 750 mva interrupting rating for application on 13.8 kv systems at 1200/2000 amp continuous

I-T-E Type	Continuous Amperes	Rated KV	Interrupting MVA
5HV-75	**1200**	4.16	**75**
5HV-150	600-1200-2000	4.16	150
5HV-250	1200-2000	4.16	250
5HV-350	**1200-3000**		**350**
7.5HV-250	1200-2000	7.2	250
7.5HV-500	1200-2000	7.2	500
15HV-150	600-1200	13.8	150
15HV-250	1200-2000	13.8	250
15HV-500	1200-2000	13.8	500
15HV-750	**1200-2000**		**750**

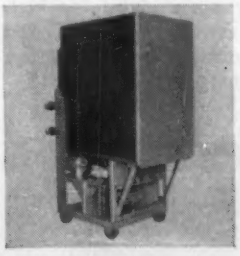
Note: These ratings require no change in I-T-E compartment dimensions.



5HV-75



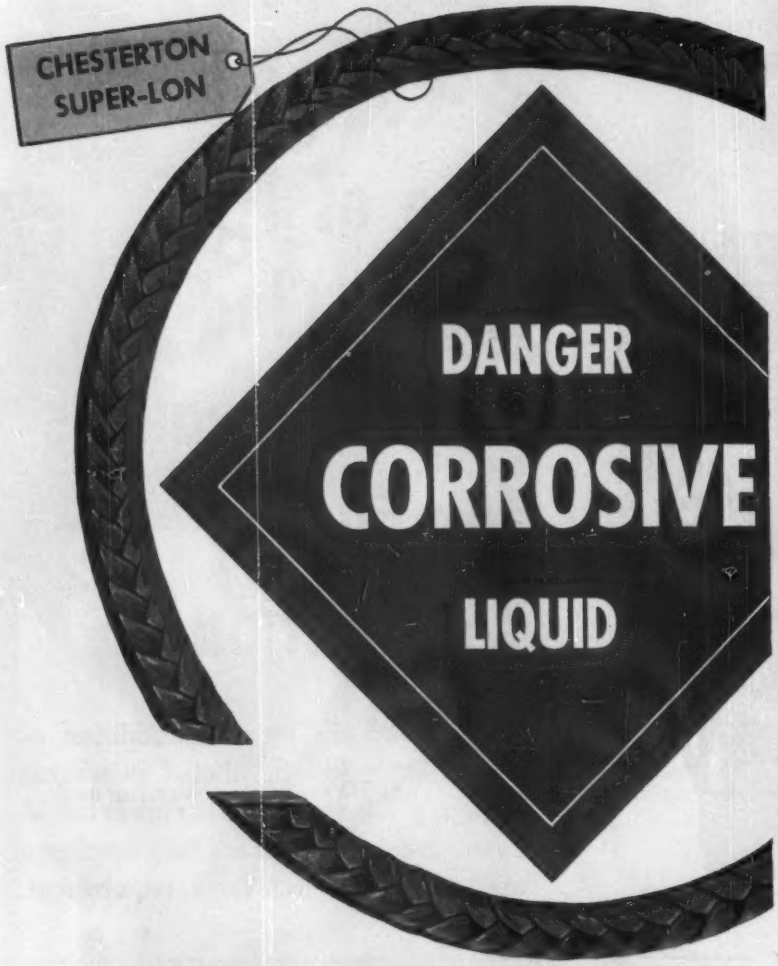
5HV-350



15HV-750

For complete information, call your nearest I-T-E sales office. Or write I-T-E Circuit Breaker Company, 19th & Hamilton Streets, Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY • Switchgear Division



Do you use TEFLON PACKINGS in your plant?

SUPER-LON stands all corrosive chemicals up to 550°F with the exception of molten alkali metals.

Super-Lon is a new packing by Chesterton which far surpasses the old white resin type Teflon Packing as originally introduced. This is Teflon* Fibre — 30 times stronger than old fashioned moulded Teflon resin. The finer, stronger filament yarn gives more tensil strength, less surface friction.

Alternated with Chesterton Style 318, Super-Lon works marvelously on high speed shafts handling hot corrosives. It is far less expensive than old style Teflon and unequalled in stationary service. Send us your packing problems. We can give you the *right* packing to solve your "unsolvable" headaches.

*Dupont Trademark

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A. W. CHESTERTON CO. • EVERETT 49, MASS.
America's Oldest Manufacturer of Mechanical Packings

C-V PUMPS

Continued from page 198

than routine lubrication and replacement of worn parts. Operating experience should determine life expectancy of rod bushings, packings, plungers, ball checks and seats. A schedule, based on this experience, should be set up to replace wearing parts, rather than let them fail in service. Preventive maintenance can be scheduled for convenience. It's no secret that breakdown maintenance always comes at the wrong time and is generally an expensive business.

Lubricate moving and sliding parts at least once per 24 hours pumps are in continuous operation. Do it in proportion to operation on any other basis. Check the entire pump at least once per 24 hour until, from experience, you can set up an inspection schedule to fit your operating conditions. Such maintenance means almost no downtime for emergency repairs. Emergencies happen, but we can prepare for these, too. A planned logical sequence of steps, such as a trouble-shooting chart, p 127, can take a lot of the sting out of an emergency breakdown.

The stuffing box is perhaps the most important maintenance point. Poor installation and improper break-in of packing causes excessive leakage and, if the liquid is corrosive, premature failure of the pump. And packing won't last long in contact with a rough plunger. Polishing on a lathe takes care of a lightly scored plunger, but replace it if it's badly scored.

Crosshead-plunger-assembly fit into the pump frame can be another sore spot when replacing packing. If it fits too loose, the packing, instead of the crosshead, supports plunger weight. Then the plunger drags on the lantern gland of stung box throat, scoring the plunger and chewing the packing. Replacing packing can't be a hit-or-miss job. It's important to follow manufacturer's instructions for the right packing and right break-in procedure.

Modern controlled-volume pumps are precision metering devices. Their installation and maintenance should be considered no less important than the part they play in the plant process.

To consolidate and expand programs of basic research in the fields of chemistry, physics and nuclear energy, Mine Safety Appliances Co has formed a wholly-owned subsidiary, MSA Research Corp.

Orlando Utilities Commission, Orlando, Florida, has ordered two gas turbine-generator sets with combined capacity of 33,000 kw from General Electric Co's Gas Turbine Dept in Schenectady, N. Y.

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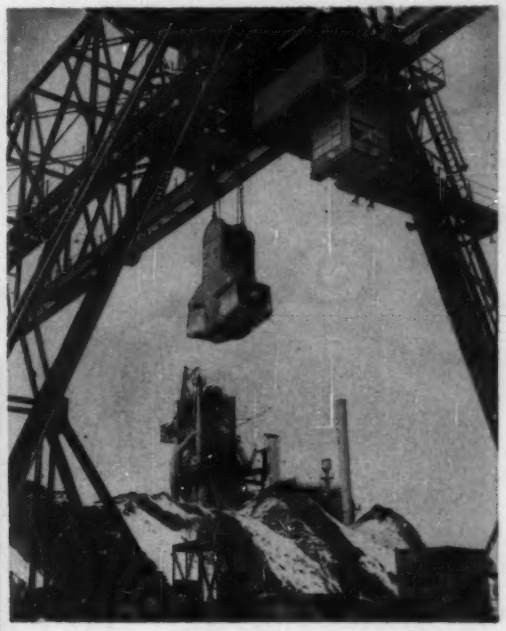
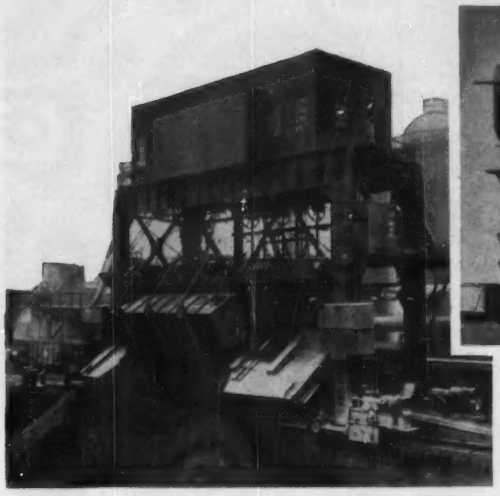
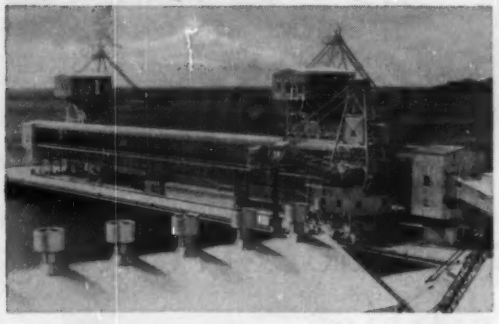




We at H&P blend progressive and imaginative design with technical and manufacturing experience gained from 70 years of designing and building dependable

BULK MATERIALS HANDLING EQUIPMENT.



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- Ore and Coal Bridges
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- Coal Preparation Plants
- Coal and Coke Handling Equipment
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- Wet Cyclones
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Why Pritchard? Because Pritchard has the experience so necessary to the successful completion of such a project. Pritchard people *know* the power industry from years of experience in designing and building power plants. What's more, Pritchard offers you the popular Single Responsibility Contract, which benefits you four ways. 1. You know the cost before the job begins. 2. You have a firm guarantee of operation and efficiency of the completed plant. 3. You realize greater savings from coordinated purchase of materials. 4. You realize a faster return on your investment because of earlier completion date.

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J. F. PRITCHARD & COMPANY
4625 Roanoke Parkway Kansas City 12, Mo.

Pritchard's ability to enlarge and modernize power plants has been proved!

The giant power plant for National Petro-Chemicals Corporation's Tuscola, Illinois plant is just one of many successful Pritchard installations.

The plant was designed, engineered and built by Pritchard under the popular Pritchard Single Responsibility Contract, working with the client's staff.

This experience is available to you!

When you plan to expand, modernize or construct new facilities in your power plant, contact Pritchard *first*.

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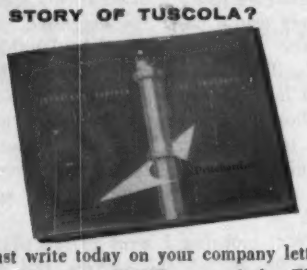

Just write today on your company letterhead for your FREE copy of the TUSCOLA BROCHURE. In it you will find a picture story of the world's largest petro-chemical plant, including the power facilities.

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SERVING THE GAS, POWER, PETROLEUM AND CHEMICAL INDUSTRIES
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MARMADUKE

Continued from page 156

fines, with biggest pieces about ½-in. diameter. He had been mixing coal with the breeze because they never had enough breeze to burn alone. But the mixture coked, then caked to the grates, giving his power engineer all kinds of trouble.

"They experimented with various coal mixtures. A smaller percentage of coke breeze usually gave best results. They tried thin fires, then more forced draft and stoker speed to hold the load. And they tried the opposite; thicker fire bed with slower stoker speed and less draft.

"At times, because of load and a higher percentage of coal mix, they had to put a man on each shift just to keep the ashpit from plugging. That's because it seemed that more stuff was going into the ashpits than into the fuel hoppers. This was caused by bad coking and caking of coal on grates which swelled the mixture, increased the volume.

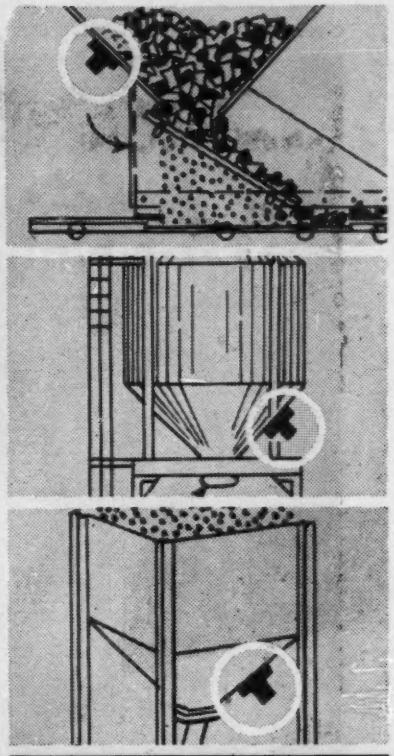
"Various coal companies were called in from time to time. They'd study the problem, recommend a certain coal, then send out a few truck loads for trial. Next day their combustion engineer would show up to run a test.

"The plant wanted two results. First, no coking on the grates. Second, no excessive temperatures that would fuse the brickwork. But each trial brought headaches. Some coals burned with such intense heat at the hopper outlet that the brick near the movable hopper gates burned badly. Fire would actually back into the stoker fuel hopper. During those tests, Godly's chief engineer would check temperatures in front, center and rear parts of the furnace with an optical pyrometer aimed through an observation port. Some coals would burn too fast, with too high a temperature. Ignition, bullnose and roof arches wouldn't stand up. Grates also became too hot and were still hot after returning to the front.

"While the chief was making these temperature checks, the operators took orsat tests of furnace gases. These tests varied widely, depending on the load.

"Usually a change in draft pressure caused a wide change in CO_2 percentages. So burning mixtures of coal and coke breeze on a grate designed for coke breeze alone kept Godly's boiler-house gang on a merry-go-round.

"About a year before, the plant had to start burning all coal. Reason: the coal company had to meet a customer demand for breeze production on a large contract. Because the food-processing plant business was peanuts by



You really *don't* need that *sledge hammer*

to keep coal moving smoothly through storage and into your fire box. The *engineered installation* of Cleveland Vibrators on...

Chutes Hoppers
Bunkers Bins
Tubes...

will eliminate delays and save man hours by providing a steady flow of fuel, automatically.

Write for detailed information on our complete line of bin vibrators for the power industry.

Air or Electric
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ONE OF THE GARLOCK 2,000

Chart shows loss of thickness after alternating wet and dry exposure tests. Garlock 662 returns to within 1% of original thickness. No. 662, made from a cork paper base impregnated with a synthetic rubber, is dimensionally more stable than (A) beater process sheet with synthetic rubber binder, (B and C) sheets saturated with glue-glycerine binder.

GARLOCK 662 GASKET MATERIAL does not shrink or change shape

Here's convincing proof that gaskets of Garlock 662 can stand varying climatic conditions without drying, shrinking, or hardening. The gaskets illustrated were subjected to a 24 hour alternating wet and dry test for weeks, then conditioned at room temperature. As the photo and chart at right show, 662 gaskets returned to their original shape and to within 1% of their original thickness. Competitive types hardened, twisted, and shrank as much as 8%. No wonder so many companies are specifying 662 for use against gasoline, water, and oil at temperatures up to 300°F. It is approved by Underwriters' Laboratories, Inc. for use against hazardous liquids.

And longer-lasting 662 Gasket material is only one of "the Garlock 2,000" . . . two thousand styles of gaskets, packings, and seals to meet all your needs. It's the only complete line. It's one reason you get unbiased recommendations from your Garlock representative. Call him today or write for Bulletin AD-146.

THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, *contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

MARMADUKE

Continued from page 203

comparison, the coal company stopped all breeze deliveries. So for a year they'd had a tough time keeping steam on the line—and firemen on the job.

"Now Godly's chief engineer was threatening to quit unless new coal-burning stokers were put into the furnaces. But that was a costly job for six boilers and Godly would have to do some high-pressure selling to his boss.

"When Godly finally stopped crying in his beer, the stoker salesman piped up. 'New stokers are your only solution for burning 100% coal, no question about it. We can put new stokers into those boilers, Mr Godly, and your problems will be over.'

" 'Yea,' answered Godly, with a long face, 'but I'm the guy who has to get the money from my firm—and chances are they'll tell me to look for another job if I can't find some way to burn coal on our present stokers!'

" 'What's it worth to you if I burn coal without spending a cent for new equipment?' I asked Godly.

" 'Har, har, har', guffawed the stoker salesman, almost choking on his beer. 'That's a hot one. What do you marine guys know about burning coal in stationary boilers anyway?'

" 'Plenty', I answered. 'In emergencies I've burned everything from dried camel's dung to furniture in marine and stationary boilers. And I learned one thing—you can burn anything if you know what you're doing.'

"That quieted him down. Godly looked interested. 'Suppose I get my firm to give you 5% of what this man's stokers would cost?' he suggested.

"The salesman started laughing again. 'I'll be at your plant for another good laugh when you try burning coal on those pinhole grates,' he yelled, getting up to leave. 'And what's more,' he snickered over his shoulder, 'I'll buy you a case of nose paint if you succeed.'

"Next morning I went to the plant. After examining the stokers and the boilers, I asked Godly if I could use his office telephone. After two hours of phoning, I found a coal company in Joliet, 35 miles away, that had what I wanted. They promised to have two truck loads of coal at the plant early next morning.

"Next day everyone was on hand; the stoker salesman, Godly, his chief engineer and two big shots from the front office.

" 'Mr Godly told me about your reputation as an engineer and also about your proposition,' said the superintendent. 'I told him we'll pay you 5% of what new stokers would cost. But,

Precious Jewel of Industry's Future

"Black Diamonds" are America's most valuable resource for today and tomorrow! Only Bituminous coal can fully meet industry's needs for more electrical energy and more plant-power.

Convenient reserves of B&O Bituminous offer an unlimited supply of coals for every purpose, at low-cost. *Ask our man!*

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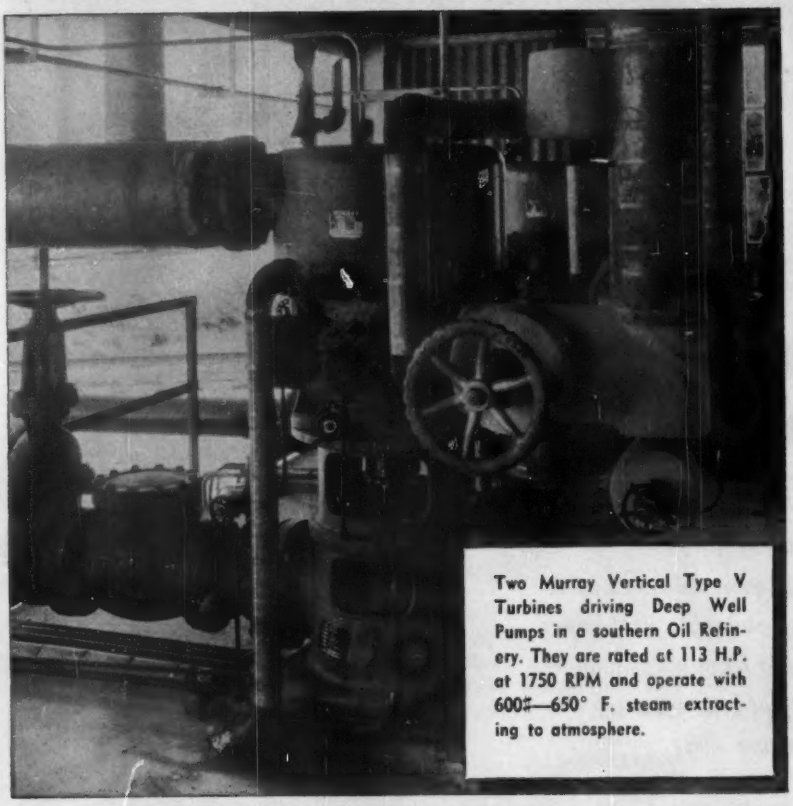
LINKING 13 GREAT STATES WITH THE NATION B&O

Murray Turbines



Two Murray Vertical Type V Turbines driving Deep Well Pumps in a southern Oil Refinery. They are rated at 113 H.P. at 1750 RPM and operate with 600#—650° F. steam extracting to atmosphere.

• Murray Vertical V turbines, both geared and direct-connected, are being used more and more for driving vertical pumps of all types. The Murray Vertical V turbine is designed from top to bottom as a vertical turbine, not just a horizontal turbine, "upended." The Murray Vertical is especially constructed and arranged for vertical mounting.

Murray vertical turbines can be furnished for steam pressures up to 600# 750° F. TT. and back pressures as high as 100# and can carry most normal thrust loads imposed by vertical pumps.

MURRAY IRON WORKS COMPANY

BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

MARMADUKE

Continued from page 204

naturally, we first want to be absolutely sure you completely solve our problem. After all, we've been having trouble for years.'

"'OK', I told the chief. 'Clean out your hoppers and fill them with this new coal.'

"Three boilers were on the line at the time. Their hoppers were cleaned out and filled with the new coal. Soon as it started to burn, you could tell the difference. The chief had his pyrometer ready. But the coal burned with an even temperature throughout the fuel bed—just like the 100% coke breeze that the stokers were designed for. There was no excessive heat at the furnace front—or anywhere else. Best of all, the stuff burned without coking or caking.

"'Yea', chimed in the stoker salesman skeptically, a half hour later, "but how will this miracle coal burn under heavy load conditions?'

"'Let's try it and see,' I answered.

"The chief had one boiler cut out so two of his three boilers would carry the load. After another half hour everyone had to admit there was no difference in combustion. Fact is, they all agreed it was the smoothest burning fuel they ever tried, even when compared to 100% coke breeze. By noon even the salesman had to agree that this new coal did the trick.

"'Say', piped up the salesman sarcastically. 'What in hell's this miracle stuff you're burning on those pinhole stokers, anyway?'

"'Miracle stuff nothing,' I answered. 'I told you anything can be burned if you know what you're doing. That's just common, garden-variety strip coal. And it's a lot cheaper than the mixtures burned here before.'

"'Strip coal?' echoed the chief engineer, giving me a fishy look. 'Just why should cheap strip coal burn better than all the expensive, gold-plated coals we've tried before?'

"By now I was surrounded. They all wanted the answer.

"'By golly, you've really got us guessing, Mr Surfaceblow,' chimed in Clifton J Butterworth, the company's president, as everyone stretched an ear. 'Just why should a cheaper strip coal burn so well on these grates?'

"'Simple', I answered. 'Strip coal burns without coking or caking because it comes from near the surface and is already partly oxidized. You'll find the more it's oxidized, the better it'll burn on your pinhole grates. So, to solve your problem, all I had to do was find a coal company who handled strip coal.'" (*Continued on page* 208)

They licked a problem— before it happened— with STANODIESEL Oil M

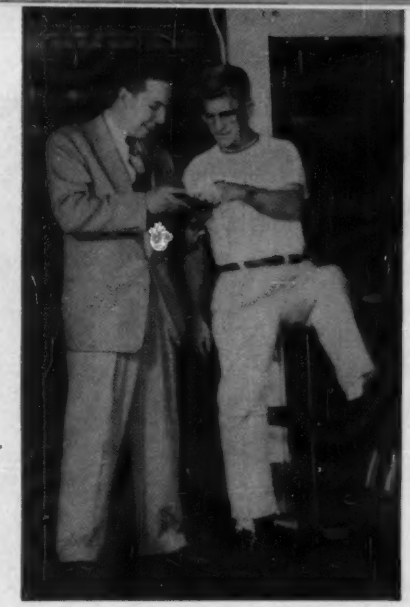
How Sturgis light plant planned ahead to eliminate source of possible power shut down

Sturgis, Michigan, light plant management in 1946 determined that it might be difficult to satisfy all power requirements if the light plant's large engine, or more than one of its small engines, was down. The plant is equipped with 5 engines—four GM 1,600 H.P. and one Busch-Sulzer 2,475 H.P. Plant management rightly figured that one of the keys to the problem was good lubrication. So, in 1946, STANODIESEL Oil M was tested in one General Motors engine.

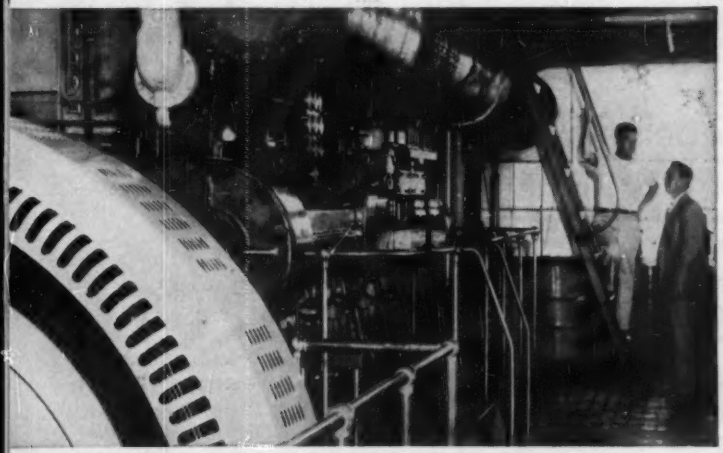
In 1947, based on its performance during the test, all engines were converted to STANODIESEL Oil M. In the nine years since, the plant has never had to shut down power to customers because of engine or oil failure. There have been no wear problems. Engines have stayed clean. There is no ring sticking. Bearing life is exceptional.

STANODIESEL Oil M can give this kind of performance for two big reasons: (1) its highest quality base stock, (2) its additive formula. STANODIESEL Oil M has superior stability. An oxidation inhibitor helps to prevent unwanted increases in oil viscosity. Detergent-dispersant additives keep crankcase, pistons, cylinder walls and other parts clean. An anti-foam agent controls foam.

There's a Standard Oil industrial lubrication specialist near you in any of the 15 Midwest or Rocky Mountain states. Call him for more information about STANODIESEL Oil M. Or write Standard Oil Company, 910 S. Michigan Avenue, Chicago 80, Illinois.



J. J. Threlfall, superintendent and Donald Cripps, Standard Oil lubrication specialist check Don's data book on Sturgis light plant diesels. Don is well qualified as a lubrication specialist. He has been doing this work for nine years. He has an engineering degree from Michigan State University and is a graduate of the Standard Oil Sales Engineering School.



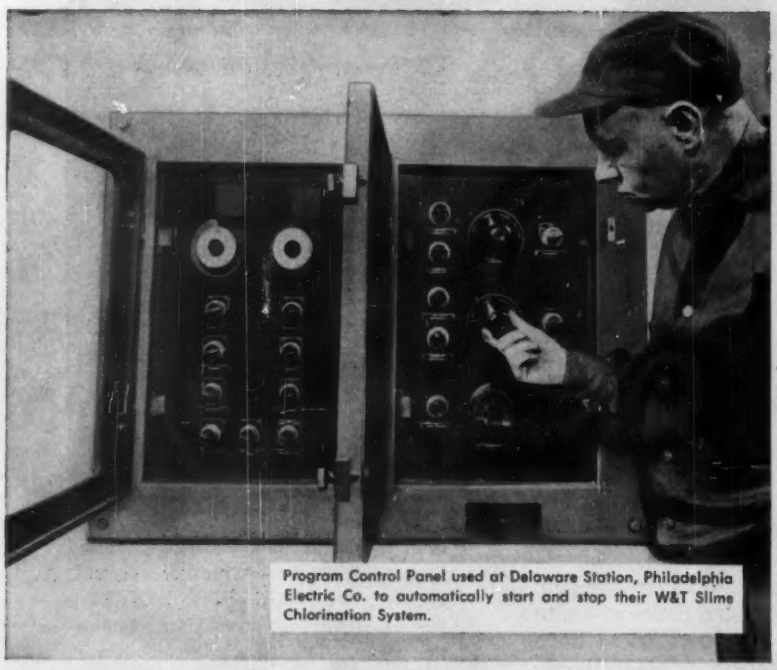
Sturgis, Michigan, light plant has four GM 1,600 H.P. engines and this Busch-Sulzer 2,475 H.P. engine. Engines receive progressive maintenance at 3,500 to 4,000 hours. STANODIESEL Oil M is used in all engines.

Quick facts about
STANODIESEL Oil M

- Keeps crankcase, pistons, cylinder walls clean.
- Combats deposit and wear problems imposed by use of economy fuels.
- Maintains film on difficult to lubricate areas and parts.
- Eliminates spark plug fouling in spark ignited engines and reduces combustion chamber ash deposits in engines burning natural gas, LPG and liquid fuels.
- Eliminates fuel injector and pump sticking caused by deposits on injector barrel and plunger where fuel and lube oil commingle.

STANDARD OIL COMPANY
(Indiana)

STANDARD



Program Control Panel used at Delaware Station, Philadelphia Electric Co. to automatically start and stop their W&T Slime Chlorination System.

HOW W&T CHLORINATION

controls slime in power generating plants

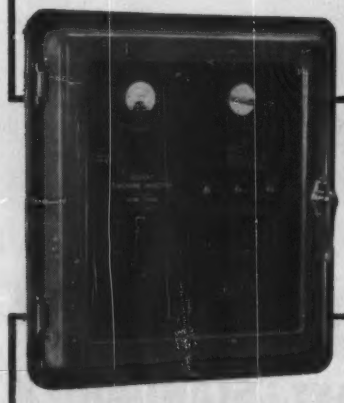
The Philadelphia Electric Co. has W&T chlorination equipment installed in their steam-electric generating stations to prevent slimes from fouling the turbine condensers and lowering the efficiency of the units. Maintaining cooling efficiency saves enough fuel to more than pay for the treatment.

Chlorination is controlled from a W&T Program Control Panel like the one pictured. Operators preselect chlorine dosage and treatment times. Chlorination is started and stopped automatically in accordance with the preselected schedule. The result is positive slime control without requiring personnel to supervise each treatment and without the expense of chlorinating continuously.

For information about W&T Slime Control Systems write for Bulletin CD-42.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY



HOW TO DETECT 3 PARTS CHLORINE IN A MILLION PARTS AIR

New W&T Solvay Chlorine Detector*

detects as little as 3 p.p.m. chlorine in a continuous air-stream sample. Automatically sets off alarm at higher concentrations.

Write for Publication 50.118

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25 MAIN ST., BELLEVILLE 9, N. J.

I-55 *Manufactured under patent license from Solvay Process Div., Allied Chemical & Dye Corp.

MARMADUKE

Continued from page 206

Marmy took his feet off his desk, yawned, then roared again. "The salesman turned out to be a good Joe. He had a case of Sandpaper Gin delivered aboard my ship that afternoon as promised. Godly kept his job as plant engineer. Butterworth came aboard before we shoved off for Duluth that evening and handed me a check for $900, then had dinner with us in the officer's messroom.

"Next trip into Chicago I received a note from Godly saying that their fuel problem was completely solved, after all those years of constant headache. And they didn't have to worry about a strip-coal shortage."

With that off his chest, Marmy got back to work. The characters on the settee started raising hell again. I shoved off for my office to record Marmy's story for posterity. Now you readers can cash in on it if you have a similar problem.—*SME*

Marmy's Mailbox

'Tis here you exchange blasts with the old boy

GERMANY ACCOUNTED FOR

You should know that Marmy is read fervently in Germany. Soon as POWER arrives at our plant, we make a beeline to see what he's up to. We enjoy his sound technical advise. He's a regular guy and anybody who isn't dead from the knees up simply must chuckle over his most refreshing stories. We forget all about income-tax returns and nuclear threats when POWER arrives.

S M VOITH *Heidenheim, Germany*

GEOGRAPHY HAYWIRE

As an assiduous reader of POWER, and especially of Marmy's varied travels and experiences, please tell him Chile and Peru are on the West Coast of South America. I feel sure Marmy won't throw bilgewater on this constructive criticism.

H GROTE *San Antonio, Chile*

SANDPAPER GIN

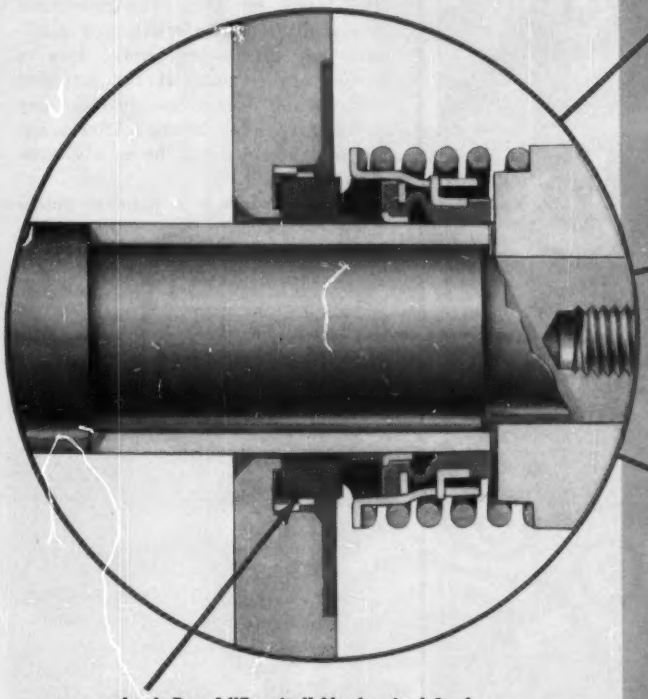
Marmy's sandpaper gin has nothing on the French Canadian's beverage; the green-glass squared-faced, John de Kyper brand. It's potent stuff.

C O VON DANNENBERG *Brooklyn, N. Y.*

EDITOR'S NOTE: Wanna bet?

A great line of pumps
all equipped with the

B&G
TROUBLE-PROOF SEAL ASSEMBLY



Leak-Proof "Remite" Mechanical Seal

This exclusive B & G feature eliminates the customary leakage which occurs where a packing gland is used. A Carbon Seal Ring faces on a "Remite" floating seat—*a new type of material, so hard it will scratch glass—wear-proof and corrosion-resistant.* Metal parts are of steel, bronze or stainless steel, depending upon the type of service. The B & G Mechanical Seal is self-lubricating.

B & G Series 1510-B
Capacities to 1100 GPM, heads to 420 ft.

B & G Series 1531-B
Capacities to 1500 GPM, heads to 420 ft.

B & G Series 1522
Capacities to 150 GPM heads to 115 ft.

Take just a moment to examine the design features of B & G Centrifugal Pumps. You'll find plenty of reasons why these pumps are giving trouble-proof performance through long years of service.

Vertical split-case construction permits removal of the bearing bracket without disconnecting pipe lines or motor leads. Solid cast iron volutes—with support feet in the larger units—effectively prevent transmission of piping strains to the motor.

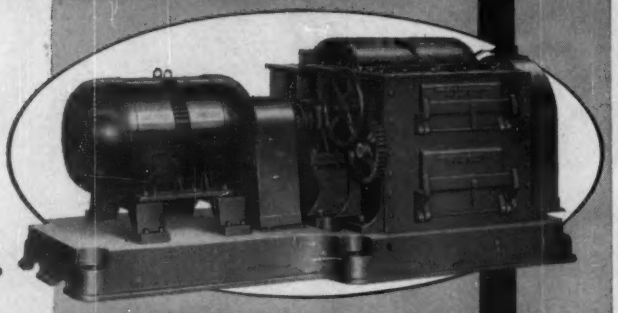
The shafts of B & G Centrifugal Pumps are an outstanding feature. Made of special alloy steel, they are super-finished and oversized to keep deflection at a minimum. The "Remite" Mechanical Seal— a B & G development—positively prevents leakage...and impellers are soundly designed to maintain hydraulic balance. An oil lubrication system, instead of grease cups, assures continuous protection to the long bronze bearings of these pumps.

B & G Centrifugal Pumps are available as all-iron, bronze-fitted, all-bronze and stainless steel units and in capacities which adapt them to a wide range of industrial applications.

Send for complete data on these three outstanding centrifugal pumps

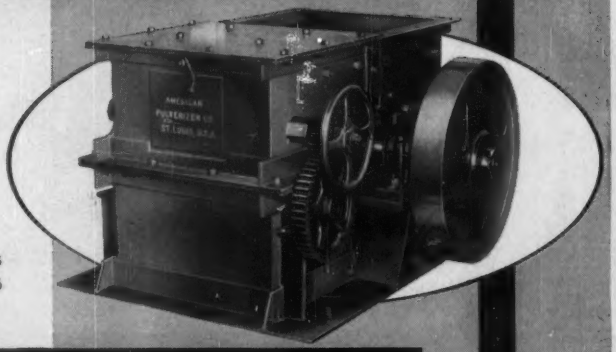
BELL & GOSSETT
COMPANY
Dept. EP-36, Morton Grove, Illinois
Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, W. Toronto

When You Figure . . .



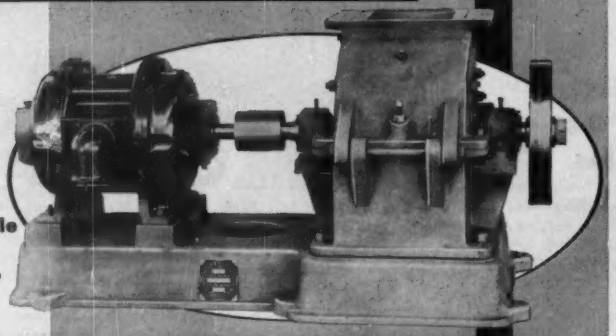
AC Series
capacities to
800 TPH

Reduction
Cost Per Ton . . .



WC Series
capacities to
90 TPH

the Best Answers*. . .



Coal Sample Crushers
capacities to
2000 Lbs.
Per Hr.

Come from *American*
Ring Coal Crushers

*In a recent independent survey, it was found that American Crushers reduced over 61,000,000 tons of coal at a parts replacement cost (including standby parts) of *less than 1/10th of 1¢ per ton.*

THERE CAN BE NO BETTER PROOF OF AMERICAN QUALITY!

American
PULVERIZER COMPANY

WRITE for Literature on These Crushers

Originators and Manufacturers of Ring Crushers and Pulverizers

1349 MACKLIND AVE. • ST. LOUIS 10, MO.

ACCELEROMETER

Continued from page 131

be 200 rpm per minute. We wanted to use the highest practicable capacitance value to get enough current for stable and reliable amplification but, for several reasons — one being physical size limitations — we had to settle for a 3.0 mfd size. This gave us a charging current of only 0.000000005 amp at the full scale indication of 200 rpm per minute.

Measuring this small current was solved by going to a relatively new negative feedback-type current amplifier. This was a big help. The instrument was available commercially and didn't need any development work. Due to exceptional stability of the amplifier our operator doesn't have to make any preliminary adjustments. After plugging in the connector, he merely turns a switch.

Speed recorder is a standard potentiometer-type instrument with an electronic null balance system. It has a scale range of 0-2000 rpm, corresponding to dc input voltage of 0-10 millivolts. This voltage is picked up across a voltage divider in the filter output. The divider is designed so that when the previously mentioned 0.9 volt is present at the filter output at a speed of 1800 rpm, a voltage of 9.0 millivolts is applied to the recorder. This corresponds to 1800 rpm on the recorder scale.

Other methods probably would have done the job. We felt, though, that using the tachometer generators as primary pick-up devices in conjunction with a portable assembly, allowing plug-in where needed, was the most economical answer. It meant number of units to be bought and maintained, and amount of labor and material needed for installation would be kept to a minimum.

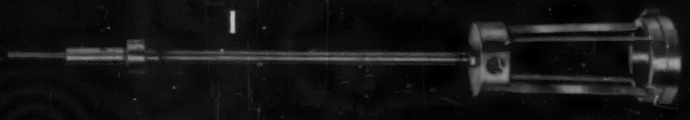
"Boy! The way I figure it, I'll make chief in only 57 years."

NOW... no knife edges to cut performance

NEW... Displacement-Type LIQUID LEVEL CONTROLLER

Nobody thought it could be done: In one sweeping new approach Kieley & Mueller has eliminated the knife edge . . . biggest trouble spot in displacement principle instrumentation.

In place of knife edges which dull in time, the K&M Flexotrol introduces the *torque table*. It's perfectly centered always . . . requires less torque. It's free-turning . . . only 4° required. Yet it doesn't have a single spot for gunk to collect requiring maintenance, affecting accuracy. A torque tube is employed . . . still the controller is



actuated by a torque rod that does not twist. Both torque tube and torsion table legs are Inconel-X . . . a special material resisting corrosion and fatigue alike. Five million cycles has shown no detrimental effect.

The full story is in Bulletin 456-1. Send for your copy.

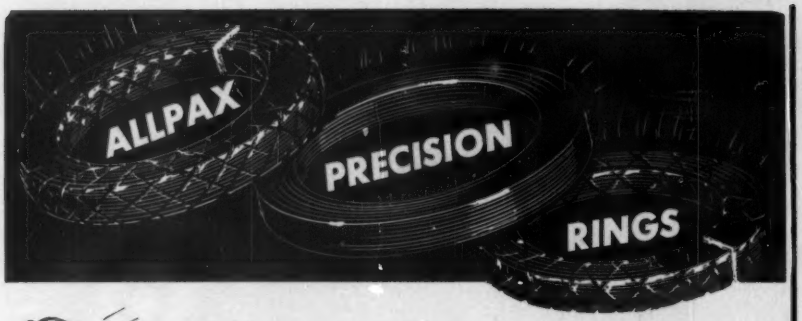
For installation and operating convenience, the *Flexotrol* Controller is reversible and rotatable . . . but something more: optional mechanical indication, independent of the pneumatic system, is your final and positive check. Available with all control features including automatic reset.

KIELEY & MUELLER, INCORPORATED

K&M

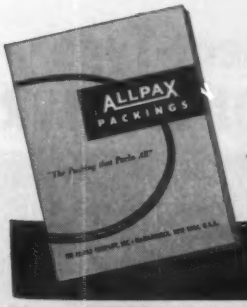
64 Genung Street • Middletown, New York

diaphragm control valves and regulators for over 75 years



ALLPAX RINGS THE BELL!

ALLPAX Rings the Bell with the development of precision packing rings, designed for performance, and made of the finest materials available. Whether open-end or solid molded type, ALLPAX packing rings are precision made to your exact specifications. They increase efficiency because they give better service. Sample rings sent upon request.



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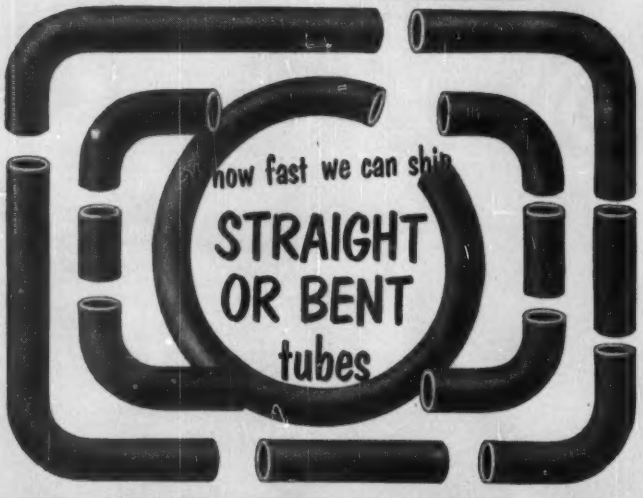
You'll be aMAZEd . .



BOILER TUBE CO. OF AMERICA
McKEES ROCKS, PA.
(Pittsburgh District)
PITTSBURGH • CHICAGO • FRED S. RENAULD & CO. LOS ANGELES

My biggest boner . . .

happened to the third-assistant engineer while I was second-assistant aboard the turbo-electric tanker *Palo Alto*. That ship had a steam turbine auxiliary power generator coupled to a dc generator. This dc generator supplied the field for both the main propulsion turbine and main propulsion generator, as well as the auxiliary generator. Connected directly to this dc generator was a small excitation generator for energizing the field of the dc generator.

One evening, while sailing up the Atlantic coast, the entire plant suddenly blacked out. All motors stopped, main engine conked out and the entire ship went dead. I rushed below with my flashlight and found the surprised third-assistant holding the end shield of the small excitation generator in his hand.

He had been cleaning the brushes of the generator and had just pulled the end shield off. That pulled the brushes off the commutator, which in turn cut the fields to the dc generator. This cut the fields to the auxiliary generator, main propulsion generator and main propulsion motor.

I couldn't stop laughing while getting the other auxiliary set started. And he had to hold the end shield until the auxiliary turbine stopped completely before he could put the end shield back. We did get the plant in operation before the auxiliary turbine stopped though. Needless to say, we never had that trouble again.

H J PFEIFER *Schenectady, N. Y.*

LUBRICATION

Continued from page 133

doubt our man was enjoying the self-satisfaction of having given the motor a good greasing. Little did he realize that when we had the motor's end cover removed, bearing's inside face was covered with gobs of grease that had been forced through the seal.

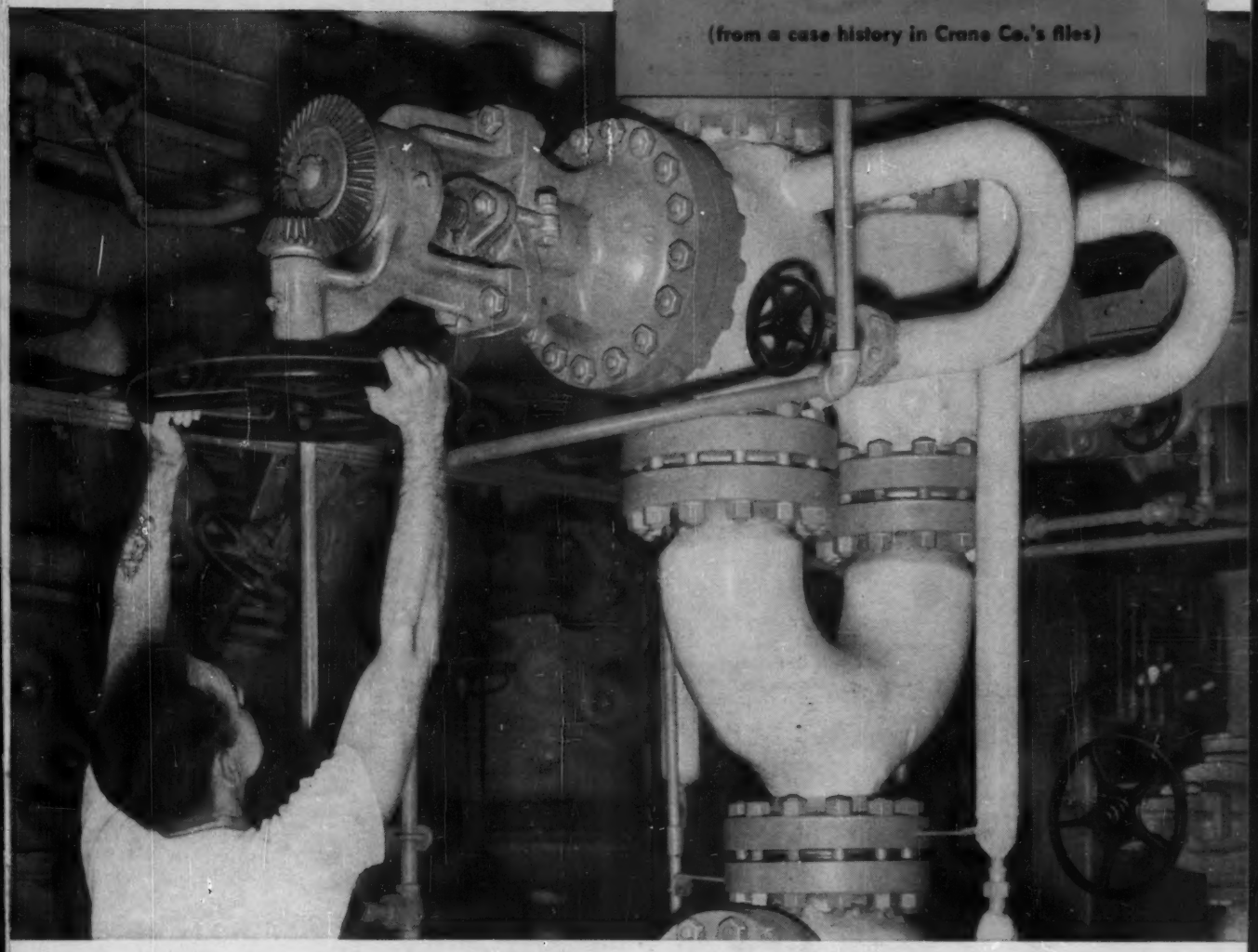
If I hadn't happened along to observe the start of this little tragedy—and tragedy it would have been soon after the fan started—here would have been another nasty complaint to untangle. It might have started like this: "Your grease is running out all over the windings. Don't you have a grease with a higher melting point?"

Moral of this incident, which is re-

(*Continued on page* 216)

INTERESTING FACTS ON VALVE PERFORMANCE

(from a case history in Crane Co.'s files)



14-year proof of low-cost valve performance on feed water

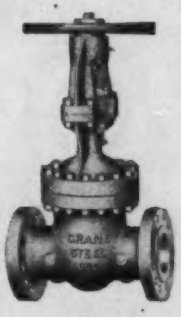
How does a modern utility hold down valve costs?

Central Power & Light Co., Corpus Christi, Texas, has proof of one way to do it: through the rugged dependability of Crane valves like the one shown above.

Fourteen years ago, Central Power installed this Crane No. 76XR valve on the feedwater pump discharge line at its Nueces Bay Station in Corpus Christi, Texas. The valve is a 6-inch gear-operated gate type. Consider its record: since 1942, this Crane valve has been handling feed water at 600 psi., 400° F. Maintenance? *None whatsoever*—the valve hasn't leaked once in 14 years, and is closing as tightly and smoothly as the day it went on the line.

In selecting your all-important valves, don't be misled by outside appearances. What counts in valve performance are *inside*—precision machining, superior materials, expert assembly and testing. That's why Crane valves are preferred throughout industry—and why Crane has been a leading valve manufacturer for over a century.

For full information on the big, complete Crane line, contact your local Crane Representative or write to address below.



CRANE VALVES & FITTINGS

PIPE • KITCHENS • PLUMBING • HEATING

More Facts on Steel Gate Valves—See Over

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

Better qualified for power services because of better inside quality

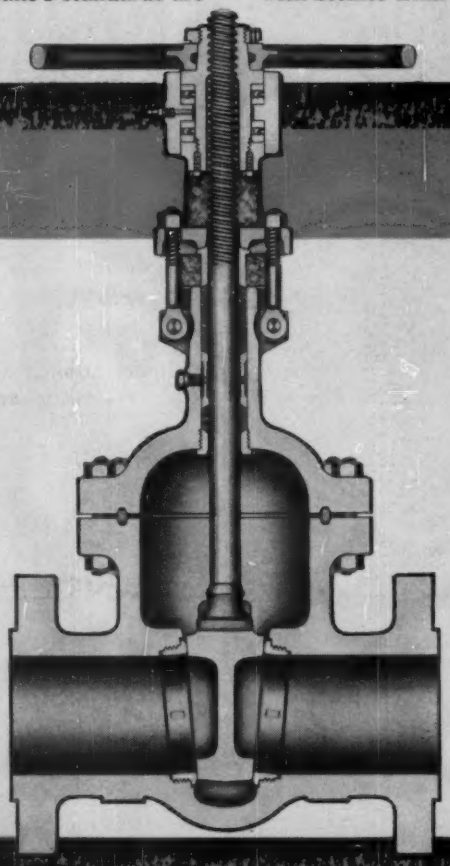
CRANE STEEL GATE VALVES

Performance like that demonstrated on the preceding page comes only from superior inside quality. In Crane steel valves, this quality is guarded with unusual skills and facilities.

In design, Crane draws on a hundred-year background in valve engineering. In the foundry, Crane works with the know-how of a pioneer and developer of steel valve casting techniques. In machining, assembling and testing, Crane's standards are unexcelled.

The 600-Pound pattern shown below speaks for the complete Crane steel gate family. In each feature there's greater assurance of dependable flow control at low cost.

For steam, water, air, and general services, Crane recommends these valves with Exelloy to No. 49 nickel alloy seating. For oil and oil vapor, Exelloy to Exelloy seating is recommended. Also available with Stellite trim.



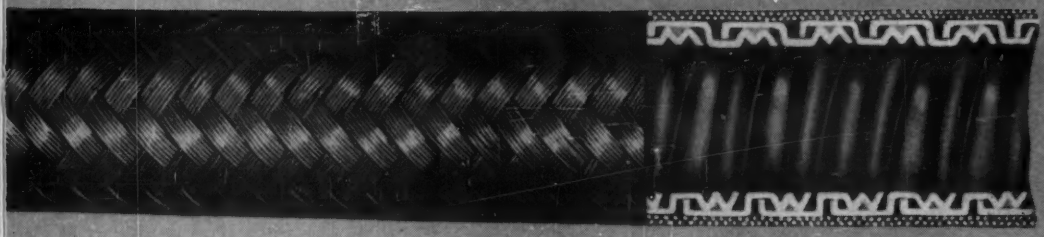
1. Note rugged proportions of stem; yet, Crane gives it added strength with heat-treating. Threads are precision-cut, long, generously engaged with yoke sleeve.
2. Two-piece ball-type gland and gland flange unit maintains uniform loading on packing and prevents binding on stem, even if bolts are pulled up unevenly.
3. Swing-out eye bolts on the packing gland flange simplify repacking.
4. T-head disc-stem connection prevents lateral strains on stem; gives lasting, smooth operation.
5. Full-length, close-fitting disc guides maintain accurate seating and reduce wear on seating surfaces.
6. Handwheel is strong, malleable iron—rigidly mounted. Designed for firm, comfortable grip.
7. Deep stuffing box with high grade packing assures tight stem seal, long packing life.
8. Note the strong body, bonnet, and end flanges. All valves 400-pound and over have ring-type bonnet joint. All bonnets have stem-hole bushing.
9. Body seat rings are replaceable should that be needed.
10. Heavy section body has added reinforcement at points of stress. Ports are straight-through, minimizing flow resistance, turbulence, and erosive action.

600-pound Crane steel gate pattern (cross section)

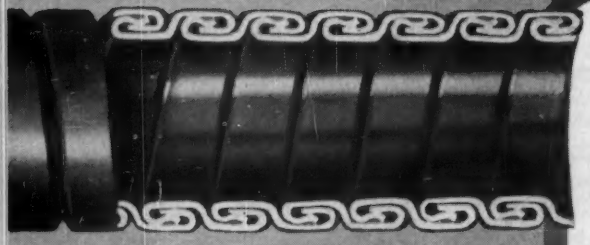
Crane cast steel gate valves are regularly supplied in 150-, 300-, 400-, 600-, 900-, 1500- and 2500-pound pressure classes. Sizes up to 24 in. Screwed, flanged or welding ends. Companion lines of globe, angle and check valves also regularly available.

Your complete guide to valve selection—steel, alloy, iron or bronze

There's no better place than your Crane Catalog to find the valves and fittings best suited to your piping requirements. It gives you the world's largest selection, complete with service recommendations and all specification data in handy, easy-to-use form. When you're ready, there's a local Crane Representative in your area on call to work with you.



TYPE FP WIRE BRAIDED



HEAVY DUTY INTERLOCKED

FLEXIBILITY

DEFIES HEAT...FATIGUE ABRASION...LEAKAGE

Penflex is ruggedly built hose with all of the flexibility required, plus the toughness and durability of metal. No matter how hot the material to be conveyed Penflex cannot be cooked like ordinary hose. It stubbornly defies rough abuse, abrasion and crushing.

From 1/8" I.D. to 24" I.D. . . . bronze, galvanized steel, or stainless steel . . . from an air compressor line to a diesel exhaust, Penflex makes them all for the power industry. And Penflex "Flexineering"—the science of applying flexible tubing to fit the particular needs of the job to be done—assures the right tube in each installation. When you require tubing or hose that is tight as a pipe, but flexible . . . safe at high temperatures . . . and free from metal fatigue, specify Penflex.

Penflex manufactures a complete line of four wall interlocked and seamless welded corrugated flexible tubing for the power industry. Write for your free copy of the booklet "Flexineering At Work."

Pennsylvania Flexible Metallic Tubing Company, Inc., 7237 Powers Lane, Phila. 42, Pa. *Branch Sales Offices:* Boston • New York • Chicago • Houston • Cleveland Los Angeles and Distributors in Principal Cities

LIGHTWEIGHT SQUARELOCKED
Unpacked, cord packed, light asbestos packed, heavy asbestos packed

TWIN-LOK
Galvanized Lined
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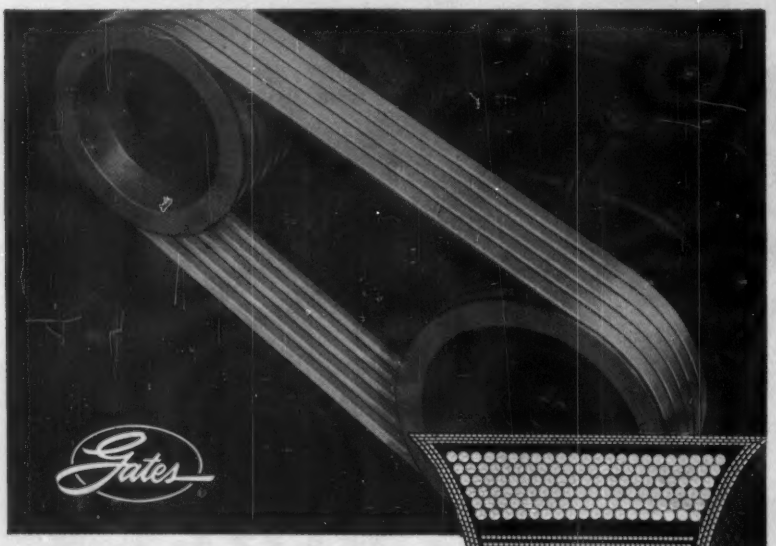
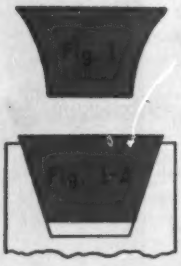
HEART OF INDUSTRYS LIFELINES

PENFLEX

METALLIC TUBING



Concave sides make V-belts last longer



The sides of every Gates V-belt (Fig. 1) are concave—a precisely engineered curve that greatly increases V-belt life. Here's why:

On the bend around the sheave, the concave sides of a Gates V-belt fill out and become straight (Fig. 1-A). Thus the belt makes full contact with the sides of the sheave, grips the sheave evenly, and wear is distributed evenly across the sides of the belt. Uniform wear lengthens belt life; keeps costs down.

Make this simple test

Take a straight-sided belt (Fig. 2) and bend it. Feel the sides at the bend; they bulge out. Now picture this bulge in the sheave groove (Fig. 2-A). It is easy to see that the belt makes uneven contact at points indicated by arrows. Naturally, wear is greater at these points. Uneven wear shortens belt life; increases belt costs.

Cut down-time and V-belt replacement costs. Specify belts that grip evenly and wear longer . . . specify Gates Vulco Rope—the V-belt with concave sides. There is a Gates distributor nearby who will quickly supply the belts you need. The Gates Rubber Co., Denver, Colorado

—World's Largest Maker of V-Belts

TPA 86

Gates VULCO ROPE Drives

LUBRICATION

Continued from page 212

peated in many other plants, is that only trained and qualified people should do lubrication. Day of the grease-monkey is past. Thoughtless workmen can do untold damage to costly modern machinery.

To cap the climax in this last plant, the lubrication supervisor had already greased these bearings correctly the previous day when motor was disassembled. It was simple for him to do the job right and make certain that the housing was not more than 1/3 full. In fact, grease wiped along the sides of a bearing before assembly is much more effective than grease applied with a gun that usually reaches the housing space.

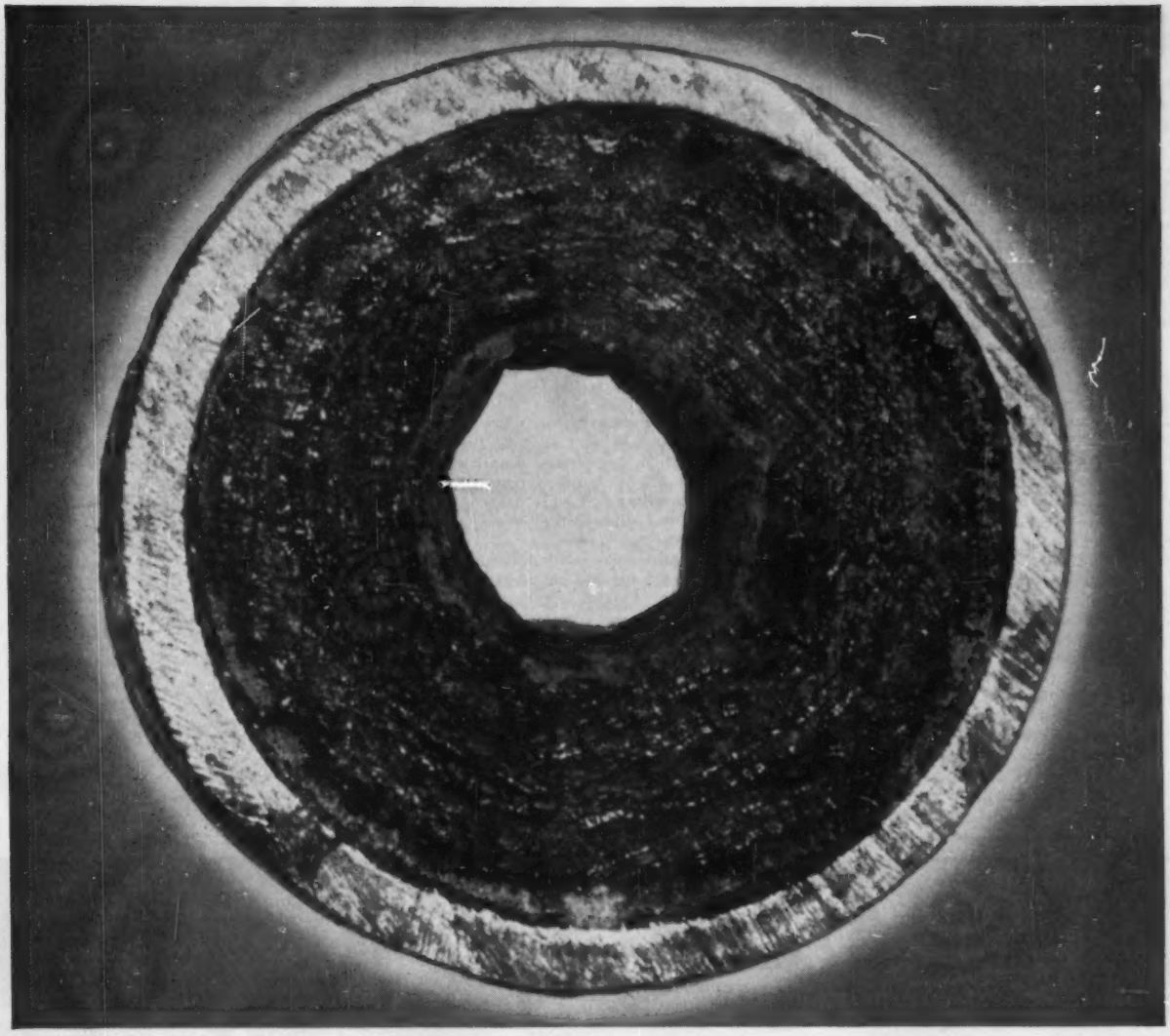
Since dirt destroys the hardened, polished surfaces, most rolling-friction bearings have seals to exclude foreign matter. This leaves no exit for excess or used grease until a seal bursts, or someone removes the relief plug. Since some bearings don't have a relief plug, it's highly important that only a small amount of very high quality grease is supplied infrequently for ball or roller bearings. Most electric-motor manufacturers recommend relubrication of motor bearings no oftener than every 6 to 12 months, unless there's an unusual operating condition like excessive water or high temperature.

Practical info available to help plan disaster control

► AN UNUSUALLY complete guide to current thinking on problems of industrial-plant security is contained in a special issue of the magazine *Civil Defender*. In it, thirty specialists contribute comprehensive articles on various phases of plant security, emergency administration, disaster control. Many of these will be of particular interest to plant-service engineers and power men.

For example, C F Petzinger, plant engineer for Cleveland Twist Drill Co, draws on his own experience with his company's outstanding personnel-shelter program for an article on "Shelters in Industrial Plants." Other articles deal with such problems as emergency control centers, repair and restoration following a disaster, preventing sabotage, testing plant disaster plans.

Single copies of this special issue "Preparation for Peacetime and Wartime Disaster in Industry" are available at $1.00 per copy, with special bulk rates available on request. Inquiries should be addressed to *Civil Defender*, Box 1641, Mobile, Alabama.



END OF THE LINE

SCALE—layer upon layer of it—has reduced the inside diameter of this pipe to practically nothing. It's a common occurrence in some power plants, and the results are costly. The line must be taken out of service. That means production loss and expensive maintenance or replacement.

Scale, sludge, carry-over, and return-line corrosion are but a few of the problems that must be overcome to assure efficiency in boiler plant operation. In Dearborn's complete line of water conditioning products, there is the correct treatment to eliminate every water trouble—the properly balanced treatment to reduce unnecessary maintenance, avoid shutdowns, and protect valuable equipment.

Since 1887, Dearborn products have provided trouble-free water to users of steam in all types of industry. That's why, today, power engineers in leading industrial plants throughout the nation look to Dearborn for consultation and assistance in solving their water treating problems.

Dearborn®

...a leader in water conditioning and corrosion control

MAIL THE COUPON

Dearborn Chemical Company, Dept. PO
Merchandise Mart Plaza, Chicago 54, Ill.
Please send me complete information on Dearborn Water Conditioning.

Name.....*Title*.....

Company.....

Address.....

City.....*Zone*....*State*.....

More FREE LITERATURE

10 **Water gages** for boiler pressures to 3300 psi are described in 6-p bulletin WG-1814. Points out how port-type arrangement and 2-color readings of the gage give greater visibility and reduced maintenance. Yarnall-Waring Co, Mermaid Ave, Philadelphia 18, Pa.

11 **Boiler gages** and accessories. Illustrated 6-p bulletin 8-1-56 contains specs and descriptions of bronze water gages, liquid-level steel gages, safety water columns, flow indicators and gage glasses. Ernst Water Column & Gage Co, 250 S Livingston Ave, Livingston, N. J.

ELECTRICAL EQUIPMENT

12 **Induction motors,** 2-pole, squirrel-cage, are subject of 6-p bulletin 05B8123A. Units are particularly adapted for boiler-feed pumps, pipeline pumps, centrifugal blowers, descaling pumps and similar applications. Allis - Chalmers Manufacturing Co, 952 S 70th St, Milwaukee, Wis.

13 **Gearmotors,** ¼ to ¾ hp, 520 to 6 rpm, are discussed in 8-p bulletin GEA-6133A. Includes selection data, dimensions, ratings, specs. General Electric Co, Schenectady 5, N. Y.

★ **Transformer instruction** booklet 427-R-1 contains 80 pages. Discusses installation, operation, component parts, maintenance and inspection of power-type transformers in all ratings. ★Request direct on company letterhead to Moloney Electric Co, 5390 Bircher Blvd, St. Louis 20, Mo.

14 **Current transformers.** Illustrated 12-p bulletin GED-3112 contains info on nine butyl-molded models, from 600-v miniature to 15,000-v outdoor type. General Electric Co, Schenectady 5, N. Y.

15 **Dry-type transformers** are subject of illustrated 8-p bulletin 155. Contains info on applications, sizes and types, construction, specs. Sorgel Electric Co, 838 W National Ave, Milwaukee 4, Wis.

★ **Capacitors** for electronic and other applications are subject of 44-p catalog 200D-3. Covers electrolytic, paper tubular, industrial, mica, ceramic, filter and motor start capacitors. ★Request direct on company letterhead to Cornell-Dubilier Electric Corp, South Plainfield, N. J.

16 **Electrical equipment** for arc furnaces. Illustrated 16-p bulletin GEA-6351 includes product info on transformers, switchgear, control and dc motors for arc-furnace application. General Electric Co, Schenectady 5, N. Y.

17 **Bushings.** Paper - oil - condenser-type units meet ASA Standards, are available in 15, 23, 34.5, 46 and 69 kv sizes. Illustrated 12-p bulletin 508 contains ratings, dimensions, specs. Lapp Insulator Co, Inc, LeRoy, N. Y.

MECHANICAL TRANSMISSION

18 **Speed reducer** engineering manual B-6727 presents application info such as hp ratings, torque capacity, overhung load values, dimensions, construction features, maintenance for single, double and triple reduction. Westinghouse Electric Corp, Box 2099, Pittsburgh 30, Pa.

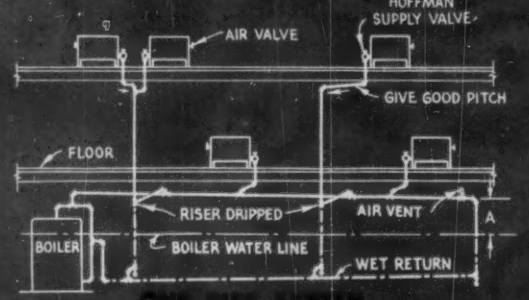
19 **Chain couplings.** Specs, dimensions, ratings and application on *Series DSC, Series SA* silent chain couplings and *Series DRC* roller chain couplings are given in 16-p bulletin C45-56. Morse Chain Co, Ithaca, N. Y.

20 **Fluid drives** for ½ to 25-hp applications are subject of illustrated 16-p bulletin 9119. Explains fluid drive principle and outlines advan-

HOFFMAN

A COMPLETE QUALITY LINE . . .

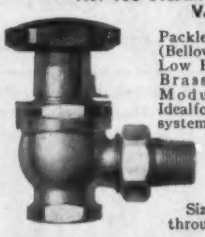
No. 1A RADIATOR STEAM VENT VALVE
Adjustable vent ports, non-vacuum. Size conn.: ⅛". Max. oper. press. 10 P.S.I.



For other one-pipe or two-pipe steam, hot water, residential or industrial systems there's a Hoffman Trap, Valve, Pump or other specially-designed device to give positive control of every requirement.

No. 75 STEAM MAIN VENT VALVE
Single Port float seals the port when water is encountered. Size conn.: ¾" male, ½" female. Max. oper. press.: 10 P.S.I.

No. 186 STEAM SUPPLY VALVE



Packless valve (Bellows Type). Low Pressure. Brass Body. Modulating. Ideal for vacuum systems.
Sizes ½" through 1¼".

50 SERIES F&T TRAP

Operating Pressures to 125 P.S.I. Cap. from 70 to 12,000 lbs. of C.P.H. Cover which can be removed without breaking piping connections. Sizes ¾" to 2".

400 SERIES DIRT STRAINER

Cast iron body with brass perforated cylinder. Made in ½" through 3" pipe sizes. Max. press. 250 P.S.I. Can also be furnished with monel or stainless steel screens.

HOFFMAN SPECIALTY MFG. CORP., 1700 West 10th Street, Indianapolis 7, Indiana

Begins on page 177

tages of the *Gyrol* units. American Blower Corp, Detroit 32, Mich.

21 **Speed reduction** Illustrated 12-p bulletin 191 describes three styles of speed reduction: integral gear-motors, speed reducers with separate motors, and speed reducers alone. Sterling Electric Motors, Inc, 5401 Telegraph Rd, Los Angeles 22, Calif.

PUMPS

22 **Proportioning pumps.** Illustrated 8-p bulletin 602 covers details and specs of *Models U* and *K* mechanical and hydraulic drive units, precision pumping units for as low as 11 cc/min, and *Model 4411* chemical pump for systems requiring limited capacities. Hills-McCanna Co, 2369 W Nelson St, Chicago, Ill.

23 **Vacuum pumps,** 3, 4, 5 stage, for use where single and 2-stage units will not economically provide suction pressures as low as desired, are described in 8-p bulletin 5H3. Schutte & Koerting Co, Dept J-Z, Cornwells Heights, Bucks Co, Pa.

24 **Self-priming pump** bulletin describes features of electric-powered closed- or open-impeller centrifugal units. Goulds Pumps, Inc, Seneca Falls, N. Y.

25 **Acid-handling pump** is described in 6-p bulletin 500. Includes info on design features, corrosion-resistant materials of construction, applications, sizes and capacities. Dorr-Oliver Inc, Barry Pl, Stamford, Conn.

WATER TREATMENT

26 **35% - hydrazine - solution,** for removing dissolved oxygen from boiler feedwater, is discussed in 16-p illustrated booklet. Olin Mathieson Chemical Corp, 460 Park Ave, New York 22, N. Y.

27 **Hot lime-zeolite** water-conditioning systems are described in 4-p bulletin 4801-A. Deals with method of operation, expected results, chemical savings, operation. Cochrane Corp, 17th St below Allegheny Ave, Philadelphia 32, Pa.

28 **Boiler-feedwater** treatment. Illustrated 4-p bulletin discusses character of water used as boiler feed, operating problems that arise, correction of these difficulties, including control procedure. Western Chemical Co, 713-15 Washington St, Kansas City 5, Mo.

29 **Deaeration.** Illustrated 4-p bulletin 4650 explains in capsule form the fundamentals of deaeration and why it is so necessary in water conditioning. Cochrane Corp, 17th St below Allegheny, Philadelphia 32, Pa.

30 **Combination unit** provides for flocculation and clarification in a single tank. It is applicable to treatment of water, sewage and industrial wastes. Illustrated 12-p bulletin 6801-R describes physical characteristics, operation, types, sizes and advantages. Dorr-Oliver Inc, Barry Pl, Stamford, Conn.

31 **Water filters.** Illustrated 10-p bulletin 909 includes dimension charts and flow curves for all three sizes of *AWF* filters and for *Poro-Stone, Poro-Screen* and *Poro-Edge* elements. R P Adams Co, Inc, 311 Park Dr, Buffalo 17, N. Y.

32 **Deaerator design** best suited for hot-water line protection in office buildings, hotels, hospitals and industrial plants, is described in 4-p bulletin 4654. Cochrane Corp, 17th St below Allegheny, Philadelphia 32, Pa.

PRIME MOVERS AND ACCESSORIES

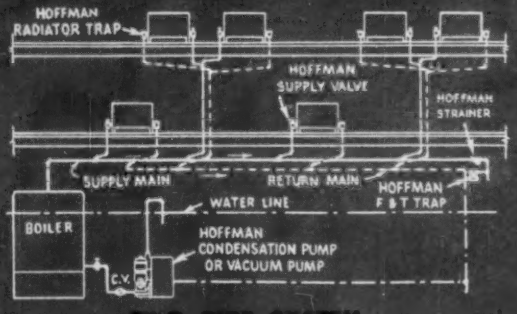
33 **Diesel engines** in ratings from 550 to 2400 hp are described in 14-p illustrated bulletin. Includes

(*Continued on page* 220)

STEAM HEATING SPECIALTIES

...A SINGLE SOURCE OF SUPPLY

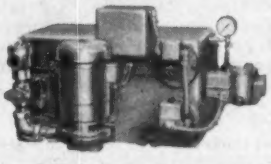
Each Hoffman product is distinguished by exclusive features that assure customer satisfaction and long, care-free service. This complete fitted quality line is backed by a dependable, single source of supply and responsibility.



THERMOSTATIC TRAPS

All brass body with renewable thermostat and seat. Max. oper. pressure from 25 through 125 lbs. Capacities from 200 through 1250 lbs. condensate per hour.

VACUUM PUMPS



Jet Type Vacuum Producer used for most effective means of simultaneously removing air and water. Receiver is of heavy cast iron. Capacities 2,500 to 100,000 sq. ft. E.D.R.

CONDENSATION PUMPS

Designed for operation at the higher pressures encountered in condensation pump service. All submerged parts are of bronze or other non-corrosive material. Cap. from 1,000 to 150,000 Sq. Ft. E.D.R.

No. 710 PRESSURE REDUCING VALVE

Single seated for continuous or dead end service. Max. high press. 250 lbs. per sq. in. Low pressure range 5 to 80 lbs. per sq. in. Sizes ½" through 1½" inclusive.

600 SERIES INVERTED BUCKET TRAP

Operating press. to 200 P.S.I. Cap. 600 to 11,000 lbs. C.P.H. All working parts connected to bonnet. Sizes ½" through 1½".

Sold by leading wholesalers of heating and plumbing equipment.

Here's the **EASY WAY TO WELD**

Small Diameter Pressure Piping

USE W-S FORGED STEEL SOCKET-WELDING FITTINGS

In addition to providing high strength and toughness, W-S Forged Steel Socket-Welding Fittings are also easy to install. Deep sockets support and align the pipe for welding... eliminating the need for tack welding or special fixtures. No back-up ring is needed either. The fillet-weld is completely outside the pipe. Welding icicles just can't form inside the pipe. The result is a clean, tight welded joint that will readily resist high pressures and the stresses of shock and vibration. What's more, installation costs are lower.

W-S Socket-Welding Fittings are available in sizes ⅛" to 4" for schedule 40, 80, 160 and double-extra heavy pipe in carbon steel, stainless steels and alloy steels.

For complete information on the installation and operation advantages of W-S Forged Steel Socket-Welding Fittings, send today for Bulletin A-3-56.

W-S FITTINGS DIVISION

H. K. PORTER COMPANY, INC.

Roselle, New Jersey

More FREE LITERATURE

Begins on page 177

photos of individual engine components, production line views, dimension charts and spec tables for three engines. Alco Products, Inc, P.O. Box 1065, Schenectady, N. Y.

34 **Reheat turbine designs** and contributing reheat experience during last 25 years is subject of 8-p illustrated bulletin 03R8467. Carries installation photos and cross section drawings of units discussed as well as cross sections through barrel type turbine for super-critical pressure application. Allis-Chalmers Mfg Co, 952 S 70th St, Milwaukee, Wis.

35 **Dual-fuel engines,** 2-cycle, 21-in. bore, are described in fully illustrated 20-p bulletin 245. Contains operating advantages and overall economy features of *Type TS-21* engine. Nordberg Manufacturing Co, Milwaukee 1, Wis.

MISCELLANEOUS

36 **Distribution systems** for automatic lubricators are described and illustrated in 12-p bulletin 4A. Bulletin describes detailed planning of systems and their applications to range of machinery. Following system from oil reservoir to lubrication point, booklet tells how and where to obtain best results from systems. Bijur Lubricating Corp, 151 W Passaic St, Rochelle Park, N. J.

37 **Grease** which is designed to stay put under conditions of dirt, moisture, low speeds and high loads is subject of 1-p bulletin 46. Includes uses, applications and physical properties. Sun Oil Co, Ltd, 85 Bloor St, Toronto 5, Ont.

38 **Electric elevators.** Underslung units are described in 6-p bulletin A-410. This conventional traction, counterweight elevator does not require a penthouse since car is lifted from beneath by a special roping arrangement. Equipment list and layouts with capacity and dimension tables are given. Otis Elevator Co, 260 11th Ave, New York 1, N. Y.

39 **Research laboratories** are described and portrayed in digest form in 24-p bulletin 48B8448. Covered are facilities involving electrical, mechanical, physics, nuclear, chemical, metallurgical and processing research projects already initiated. Allis-Chalmers Manufacturing Co, 952 S 70th St, Milwaukee, Wis.

40 **Competitive power** from the atom and capabilities to supply reactor power plants are covered in 12-p bulletin. Features a 5-p transvision of a pressurized-water reactor core built for the Army Package Power Reactor. Alco Products, Inc, Box 1065, Schenectady, N. Y.

Solve Distribution Problems

with SORGEL Substations

"Packaged" Units for Indoor Installations

Speeds Expansion and Earlier Production. SORGEL Substations are shipped complete in one or more factory-assembled units, on a substantial steel base, completely wired and tested, ready for installation and final connection. This saves the extra expense of buying separately the transformers, switches, fuses, insulators, circuit breakers, and other accessories; thereby also saving the extra labor cost and trouble when assembling and connecting on the job.

Flexibility for Future Conditions. Being all self-contained in a single unit, the Substation can be readily moved from one location to another.

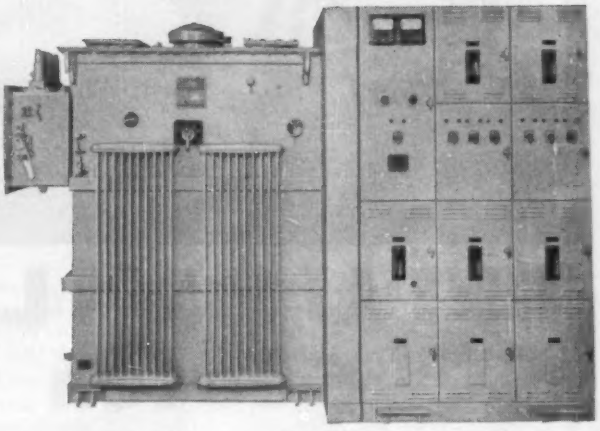
Saves Copper. The Substation can be placed near the load center, so that shorter secondary cables and smaller primary lines can be used. Improved voltage regulation and reduced line drop.

Reduces Costly Power Interruption. By locating the Substation at or near the load center, it restricts the power interruption to that area. Other areas, not affected, can continue operation.

Years of Continuous Hard Service. The rugged construction, liberal design, expert craftsmanship, sound engineering, all embodied in SORGEL transformers, have given years of continuous severe service.

Types. Either dry-type or Askarel-cooled transformers are available with any type or make of switchgear, or from any substation manufacturer.

SORGEL transformers are adaptable for any indoor installations, including hospitals, libraries, schools, institutions, office buildings, and other structures where low sound levels are an important factor.

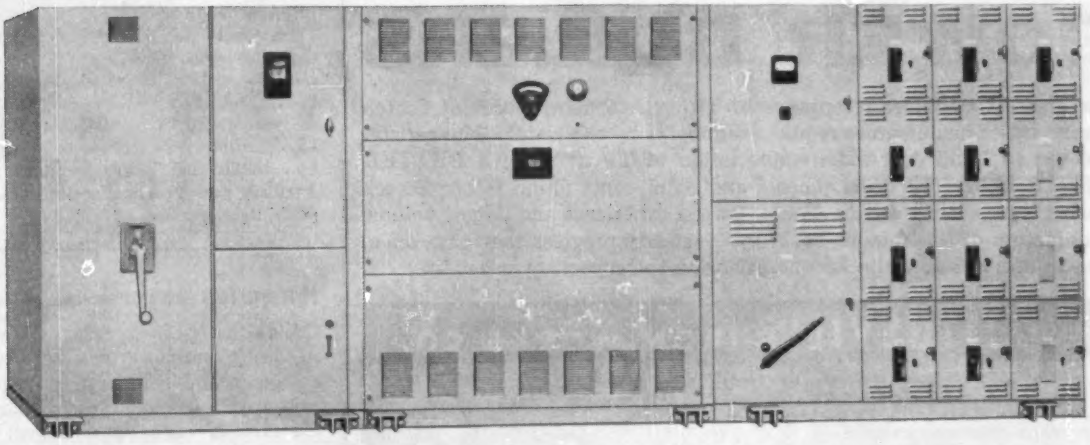


500 Kva, 13,800 volt Askarel-cooled SORGEL transformer, with primary liquid filled switch, secondary meters, and circuit breakers.

Engineered to meet your exact requirements

Not necessary to design or change your installation to fit a "standard"

Sizes up to 3000 Kva.
All voltages up to 15 KV.



2000 Kva 3-phase, 13,200 volts air-cooled dry-type transformer, with primary switchgear, metering and secondary breakers.

Sales Engineers in Principal Cities

SORGEL ELECTRIC CO., 844 West National Ave., Milwaukee 4, Wisconsin

40 years' experience in the development, manufacturing and application of transformers

TITUSVILLE
Scotch
Marine
POWER BOILERS

The greatest customer-acceptance in Titusville's many years of Scotch Marine boiler manufacture requires shipments by the trainload to satisfy! The reason is an ever-wider appreciation of Titusville as a BETTER BOILER BUY. The developments and refinements found in our Scotch Marine boilers today are the fruit of longest experience and largest volume manufacture of this famous boiler type—steady progress that pays off in *value* to every user. Write for quotations on the capacity you require.

THE TITUSVILLE IRON WORKS CO.

BOILER DIVISION
BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units
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Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters
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MACHINERY for Sheet and Structural Metal Forming . . . Tangent Benders . . . Folding Machines . . . Roller Table and Tumble Die Bending Machines . . . Press Brakes . . . Punching and Notching Machines . . . Forming Dies

A Division of
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TITUSVILLE, PENNSYLVANIA
Manufacturers of A Complete Line of Boilers for Every Heating and Power Requirement
Plants at Titusville, Pa. and Warren, Pa.
Offices in Principal Cities

REPORTS from the FIELD

Begins on page 162

Plans for the future Continued

tober, GE stole a march on the future with the opening of its million dollar bearing and lubricant center, said to be the largest test and development facility of its kind in American industry.

According to Dr Robert O Fehr, manager, mechanical engineering lab at GE, the new laboratory will permit expansion of broad research and development programs to meet the demands for faster jet engines, guided missiles, automation and advanced power generating equipment

One phase of GE's lube and bearing program for the immediate future is designed to increase the temperature range under which equipment can operate. This is to insure maximum equipment efficiency under the rigors of supersonic and arctic temperatures.

Advanced development work is also under way in anticipation of the demands of the space age. Dr Fehr offers this example of the advanced thinking of GE engineers: "Since the beginning of time, the Earth has rotated without bearings and without lubrication, held in space by mass forces. Engineers are looking for ways to apply these principles to rotating equipment of the distant future."

Diagram Key

1. Anechoic vault; **2.** Test booths; **3.** Radio influence room; **4.** 20,000 kva motor-generator set; **5.** 5200-kv surge generator; **6.** 4000-kv surge generator; **7.** 1050-kva 3-unit cascade transformer; **8.** Transformers to be tested; **9.** Power filters for sound room; **10.** 600-kv surge generator; **11.** Capacitor banks; **12.** Power regulating transformers; **13.** 200-cm sphere gap; **14.** Master switchgear; **15.** Control rooms for surge generators; **16.** 180,000-amp current generator; **17.** Auxiliary power motor-generator sets. See photo, right, p 162.

Hungarian power Continued

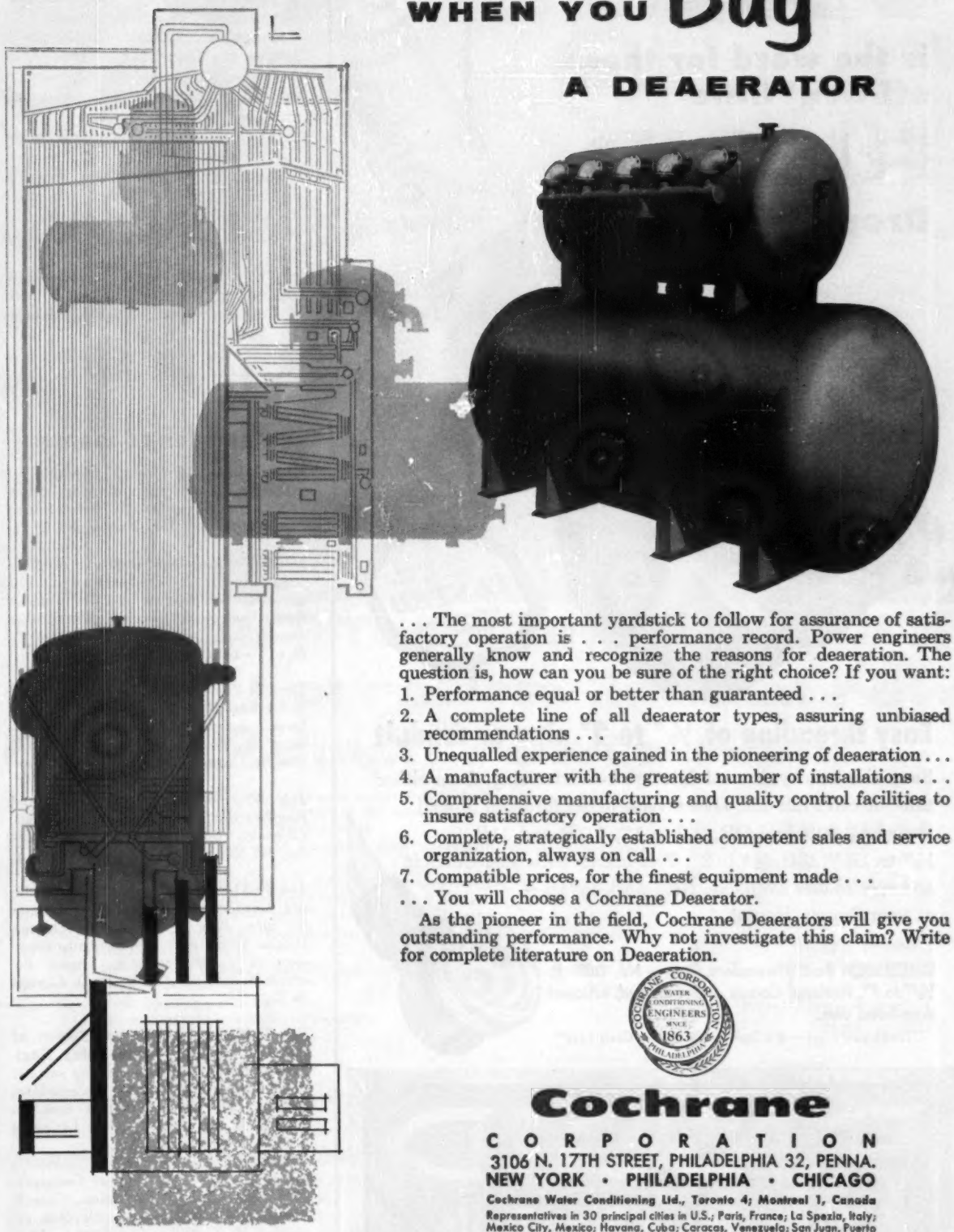
Commission meeting, held in Moscow, suggested working out a scheme for utilization of Danube waters for power projects, for irrigation systems, also for construction of dams to permit — by raising Danube water head—travel of sea vessels farther up this river.

Similar commission meetings have been slated for Hungary, Czechoslovakia and Yugoslavia.

A few weeks later, Hungary disclosed another facet of the power program. Budapest government announced that

COCHRANE . . . FIRST IN WATER CONDITIONING

WHEN YOU Buy A DEAERATOR



. . . The most important yardstick to follow for assurance of satisfactory operation is . . . performance record. Power engineers generally know and recognize the reasons for deaeration. The question is, how can you be sure of the right choice? If you want:

1. Performance equal or better than guaranteed . . .
2. A complete line of all deaerator types, assuring unbiased recommendations . . .
3. Unequalled experience gained in the pioneering of deaeration . . .
4. A manufacturer with the greatest number of installations . . .
5. Comprehensive manufacturing and quality control facilities to insure satisfactory operation . . .
6. Complete, strategically established competent sales and service organization, always on call . . .
7. Compatible prices, for the finest equipment made . . .

. . . You will choose a Cochrane Deaerator.

As the pioneer in the field, Cochrane Deaerators will give you outstanding performance. Why not investigate this claim? Write for complete literature on Deaeration.

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Cochrane

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NEW YORK • PHILADELPHIA • CHICAGO

Cochrane Water Conditioning Ltd., Toronto 4; Montreal 1, Canada

Representatives in 30 principal cities in U.S.; Paris, France; La Spezia, Italy; Mexico City, Mexico; Havana, Cuba; Caracas, Venezuela; San Juan, Puerto Rico; Honolulu, Hawaii; Manila, Philippine Islands.

Pottstown Metal Prods. Div.—Custom built carbon steel and alloy products.

Demineralizers • Zeolite Softeners • Hot Process Softeners • Hot Lime Zeolite Softeners • Dealkalizers • Reactors • Deaerators • Pressure Filters Continuous Blowoff Systems • Condensate Return Systems • Steam Specialties

FAST

is the word for these efficient little

RIDGID

Drop-Head Dies!

Easy threading of ⅛" to 2" pipe or conduit

Snap size head you want into ratchet drive ring, from either side—it can't fall out. Dies reverse easily for close-to-wall threading. 00R and OR, ⅛" to 1"; 111R and 11R, ⅛" to 1¼"; 12R, ⅛" to 2". Free carrier with sets. Conduit and special dies available. Real work-savers—at your Supply House!

RIDGID Bolt Threaders, too—No. 00R-B, ¼" to 1", National Coarse or fine thread, efficient drop-head dies.

"Threaded Pipe—*It's Tight—It's Best—Costs Less*"

RIDGID
Work-Saver Pipe Tools

The Ridge Tool Company, Elyria, Ohio, U. S. A.

REPORTS from the FIELD

Begins on page 162

it planned to replace "traditional energy sources" by atomic power.

Hungary's coal, oil and hydro-power reserves are limited and exploitation of these reserves has been rapid. Observers feel that, at the present rate of consumption, Hungary will have used up virtually all of its primary energy in about ten years.

The Hungarian government, realizing this trend and also bearing in mind the planned expansion of industry, ordered the first nuclear power plant from the Soviet Union.

If the Soviets regain control of the situation in Hungary, the groundwork of this first industrial reactor outside the Soviet Union (built by Soviets, using Soviet blueprints and installations) is to be started early in 1957.

Calendar of Events

Dec 3-5—Air Pollution Control Association, semi-annual meeting. Rice Hotel, Houston, Texas. Details from APCA, 4400 5th Ave, Pittsburgh 13, Pa.

Dec 5-7—American Institute of Mining, Metallurgical and Petroleum Engineers, 14th annual Electric Furnace Steel Conference. Morrison Hotel, Chicago. Details from AIME, 29 W 39th St, New York 18, N. Y.

Jan 21-22—Association for Applied Solar Energy, 2-day symposium on solar furnace design and operation. Hotel Westward Ho, Phoenix. Details from AASE, 3424 N Central Ave, Phoenix.

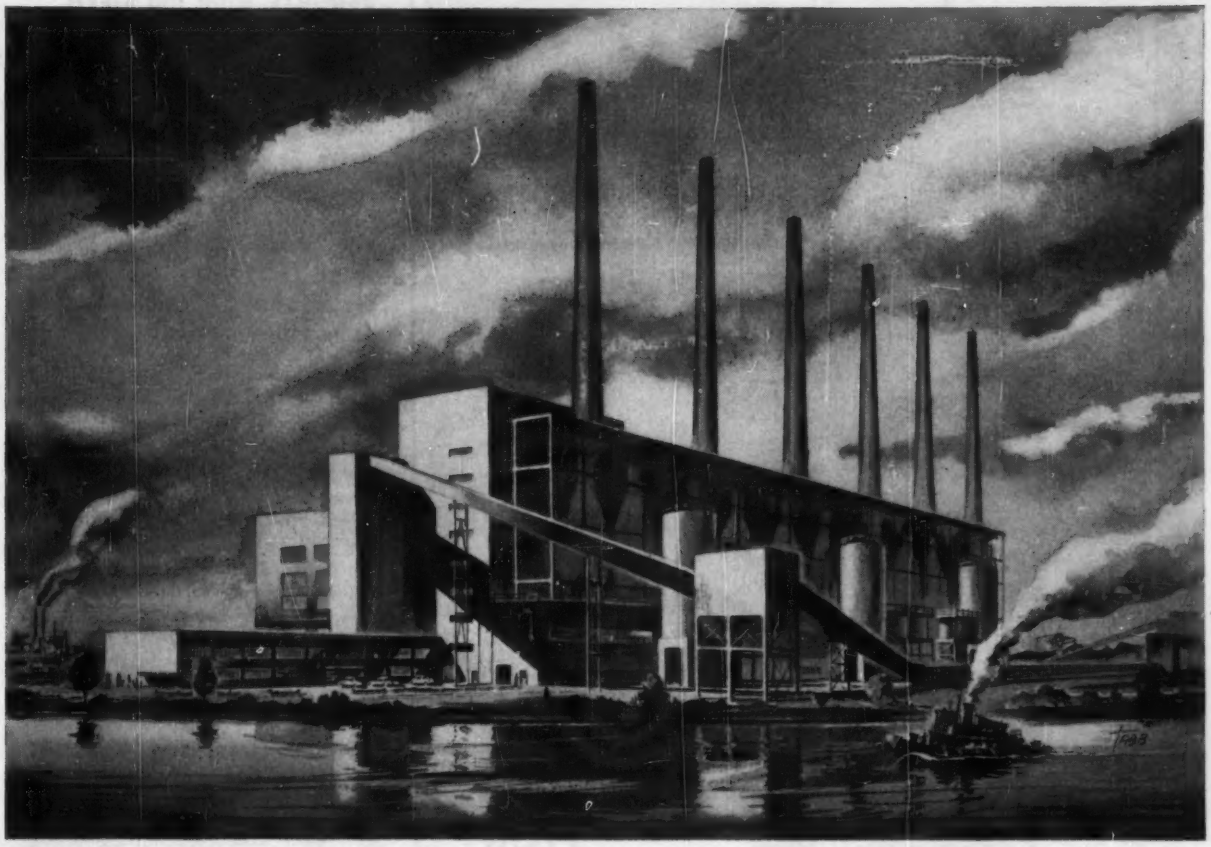
Jan 28-31—Plant Maintenance and Engineering Show. Public Auditorium, Cleveland. Details from Clapp & Poliak Inc, 341 Madison Ave, New York 17, N. Y.

Jan 30-31—3rd Annual Midwest Welding Conference. Illinois Tech Chemistry Bldg, 3255 S Dearborn St, Chicago. Details from Harry Schwartzbart, supervisor of welding research, Armour Research Foundation, 10 W 35th St, Chicago 16, Ill.

Feb 25-March 1—American Society of Heating and Air Conditioning Engineers, 13th International Heating and Air Conditioning Exposition. International Amphitreatre, Chicago. Details from International Exposition Co, 480 Lexington Ave, New York 17, N. Y.

March 11-15—1957 Nuclear Congress, International Atomic Exposition. Convention Hall, Philadelphia. Details from exposition office, 304 Architect's Bldg, Philadelphia, Pa.

March 18-19—Steel Founder's Society of America, 55th annual meeting, Drake



KEY-KAST Tee's and Ell's serve hot reheat lines at new Detroit Edison Power Plant

One of the three generating units of the new, modern River Rouge Plant of the Detroit Edison Company uses KEY-KAST Alloy Steel Welding Fittings. Hot reheat line to the turbine of this unit is fitted with KEY-KAST Tee's and 90° Ell Welding Fittings.

The high strength and long service life of KEY-KAST Alloy Steel Welding Fittings are a result of:

1. Heavy wall thickness throughout (at 27½" O.D., wall thickness is 1½").
2. Extra wall thickness at critical points to compensate for erosion.
3. Rigid dimensional and metallurgical control.

More and more power plants throughout the nation are specifying KEY-KAST fittings for their alloy piping needs.

And more and more engineers designing power plant installations are writing KEY-KAST into their specifications as a result of:

1. Desirable physical characteristics.
2. Wide variety of alloys immediately available.
3. Important cost advantages.

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DIVISION OF acf INDUSTRIES INCORPORATED

Plant: Missouri City, Texas • Mailing Address: P.O. Box 2117, Houston, Texas

For full specifications in the complete KEY-KAST line, write for Bulletin K.S. 1-52.

JOB DETAILS

Tube Size:
27½" O.D.

Material:
1¼% chrome
½% moly.

Pressure temperature:
750 psi @ 1010°F.

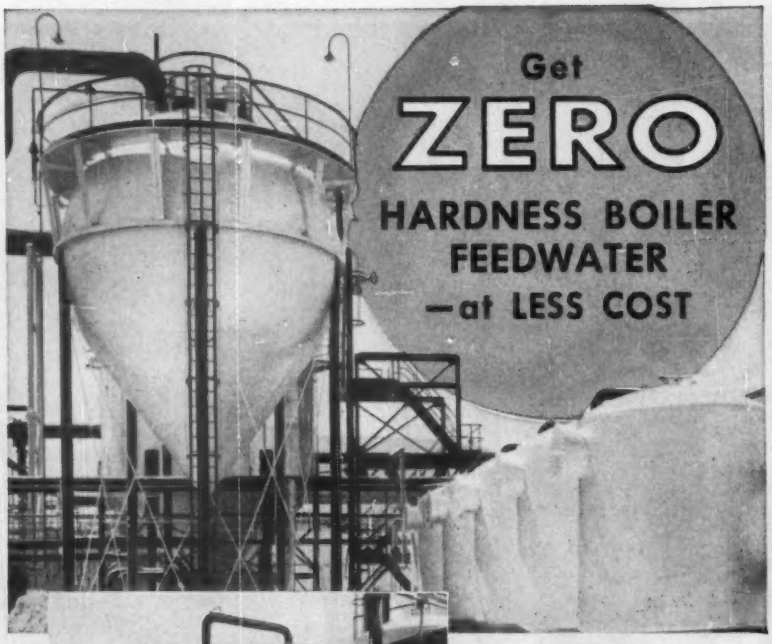
Fabricator:
Dravo Corp.
Marietta, Ohio

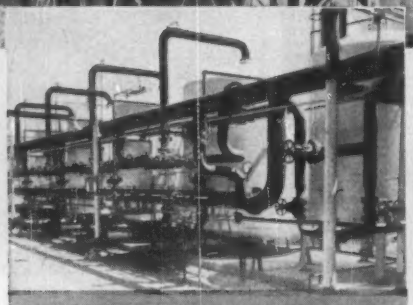
MANUFACTURING

KEY RETURN BENDS AND FITTINGS

W-K-M THROUGH-CONDUIT GATE VALVES

acf LUBRICATED PLUG VALVES





Top photo shows new outdoor hot lime-zeolite softener installation in a Southern refinery. Five Nalcite HCR ion exchange units (lower photo) have output of 470,000 gallons of zero hardness water between regenerations.

with
Nalcite® (DOWEX*) HCR
HOT LIME
ZEOLITE
TREATMENT

● Start with the simplicity of operation . . . add the low operating costs of hot lime-zeolite softening . . . all made possible by the outstanding high-temperature performance of Nalcite HCR in the zeolite softeners. Results: Zero hardness water, from virtually any raw water source, with a minimum of testing and control required. See your water treating equipment manufacturer for details on new or conversion hot lime-zeolite treatment for your plant . . . and for top softener efficiency, specify Nalcite HCR.

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Nalco® PRODUCTS

When you use Nalcite resins, you take advantage of Nalco's long and broad experience in water and process technology.

REPORTS from the FIELD

Begins on page 162

Hotel, Chicago, Ill. Details from SFSA, 606 Terminal Tower, Cleveland 13, Ohio.

March 25-29—American Society for Metals, 10th Western Metal Congress and Exposition. Pan-Pacific Auditorium, Los Angeles. Details from ASM, 7303 Euclid Ave, Cleveland, Ohio.

Brazil to build 1.1-million-kw dam on the Rio Grande

(*McGraw-Hill World News*) The Brazilian government has announced formation of a giant company to finance, construct and operate a 1.1-million-kw, mass concrete power dam at Furnas Gorge on the Rio Grande River.

New power group, to be called Furnas, will be sponsored by the federal and state government and private power concerns.

Construction on the project, which will cost an estimated $300 million, will begin early next year. It is expected that the first of ten power units (110,000 kw each) will go into operation within four years.

John Cotrim, president of Furnas, said that a recent visit to the Export-Import Bank revealed that the bank was "quite excited" about the project. It is probable that good financing will come from this source.

The dam is described by Cotrim as the first really big "joint private-governmental power project in Latin America and possibly one of the biggest power dams in the world." It is expected, first, to supply drastically needed power to Sao Paulo Belohorizonte and Rio—second, nearly double generating capacity of American Foreign Power's Peixotos project, and newly announced down-stream Estreito project, by providing enormous reservoir and regulated dry season river flow.

Cotrim revealed that Brazilian President Kubitschek ordered the job expedited because he was told that Furnas offered the only solution fulfilling his platform promise of upping Brazil's present 3-million kw capacity to 5 million by 1961—besides getting power where it is urgently needed.

Niagara-Mohawk wants to repair Schoellkopf Station

► Niagara Mohawk Power Corp of Syracuse, N. Y., has asked the Federal Power Commission for authority to rehabilitate part of the electric generating facilities damaged by June 7 rock slide at Niagara Falls, N. Y.

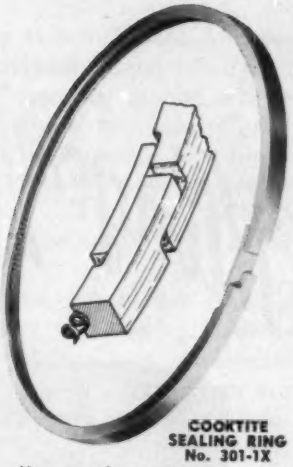
In an application for amendment of

Look to COOK for Better Rings!

Designed for ALL Sizes of Industrial Engines, Compressors and Hydraulic Equipment!

COOK PLAIN RING No. 101

Standard one-piece compression ring made of Cook Graphitic Iron with joint cut per your specification. Provides maximum seal without sacrificing strength.

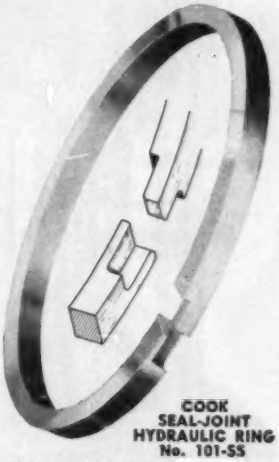


COOKTITE SEALING RING No. 301-1X

New, two-piece sealing ring made of Cook Graphitic Iron or Cookmet Bronze. Complete flexibility assures perfect wall contact at all times. No wearing period required.

COOK SEGMENTAL RING No. 104

This ring of three or more segments provides a maximum seal for compressors. It is available in Cook Graphitic Iron, Cookmet Bronze, Carbon, and Phenolic material.



COOK SEAL-JOINT HYDRAULIC RING No. 101-SS

Unique, single acting sealing ring for use in all grooves. Seal-joint construction provides unbroken sealing surfaces against both cylinder wall and groove land.

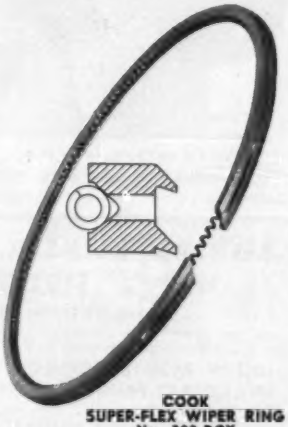
WHATEVER your piston-ring requirements — Plain, Full Sealing, Segmented or Oil Wiper — there's a "job-engineered" Cook Ring to fill the bill.

Chief among the advantages of Cook Piston Rings is Cook Graphitic Iron. An exclusive material that's made in our own foundry, Cook Graphitic Iron possesses excess carbon in the form of graphite flakes. This greasy substance eases the ring over dry spots, and helps form a hard, mirror-like surface which minimizes friction and assures *longer cylinder life, better engine performance.*

Our nation-wide Engineering Field Staff stands ready to serve you — in Baltimore, Chicago, Cleveland, Denver, Houston, Jacksonville, Joplin (Mo.), Los Angeles, New York, Tulsa and Philadelphia. Or write direct to Louisville for literature and recommendations.

COOKTITE SEALING RING No. 109

Standard two-piece sealing ring made of Cook Graphitic Iron. Advantages include single-ring groove contact and dual-ring cylinder seal. Proven remedy for blow-by.



COOK SUPER-FLEX WIPER RING No. 303-DCX

One-piece conformable oil wiper ring made of Cook Graphitic Iron. Life-time coil spring provides uniform contact pressure. Wide channel and multiple notches assure direct flow to drain holes.

C. LEE COOK COMPANY

Sealing Pressures Since 1888

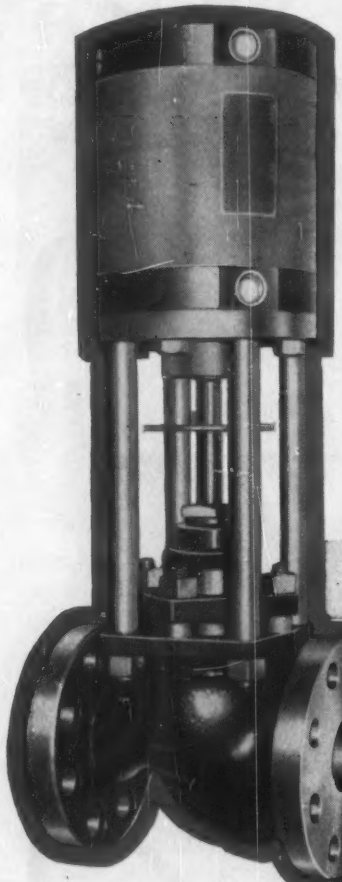
A Subsidiary of Dover Corporation

Sealing Pressures Since 1888

928 South Eighth Street

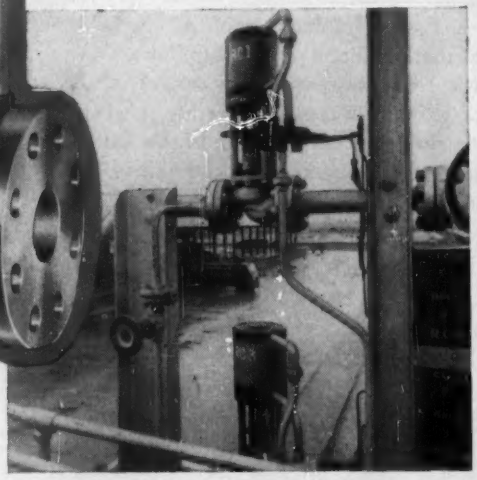
Louisville, Kentucky

Klingermatic AIR-OPERATED VALVES



The fact that the Klinger valve has no seat but is sealed by resilient packing rings which are compressed round a sliding piston, means that power is only required to move the piston from one position to another and no power is required to maintain the valve in the closed or open position. Valves are manufactured with bronze, forged or case steel bodies, screwed or flanged, with stainless steel pistons and spindles as standard, in sizes from ¼" to 6" bore. Tapped air connections are provided at each end of the air cylinder. The valves have been designed for operation with an air supply at a pressure of about 70 p.s.i., although in certain circumstances it is possible for the valves to operate at pressures down to 50 p.s.i.
Klingermatic air-operated valves are ideally suited for remote control of filling lines, emergency valves, where rapid operation is desired and such similar applications.

Write to your Klinger agent for descriptive leaflet and literature.



Klingermatic Air-operated Valves being used as remote-controlled filling and emergency valves on a gas bottling plant.

RICHARD KLINGER LIMITED, KLINGERIT WORKS,
Cables: Klingerit **SIDCUP, KENT, ENGLAND** Tel: Foots Cray 7777
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MANUFACTURERS OF KLINGER SEATLESS PISTON VALVES; KLINGER SLEEVE-PACKED COCKS; KLINGER LEVEL INDICATORS; RINGS AND SEALS IN KLINGER SYNTHETIC MATERIALS AND KLINGERIT COMPRESSED ASBESTOS SHEET JOINTINGS AND PACKINGS FOR EVERY PURPOSE

REPORTS from the FIELD

Begins on page 162

its license for its Niagara Falls hydroelectric project, company said that the rock slide substantially destroyed two hydroelectric sections at its Schoellkopf Station and damaged the third (Section 3A). Niagara Mohawk says that immediate rehabilitation and improvement of Section 3A, which has been out of operation since June 7, is economically feasible and desirable to meet requirements of its customers.

Niagara Mohawk proposes to substitute 60 cycle generators of the same kw-capacity in place of the four 25 cycle generators now in section 3A. This will provide 104,000 kw of 60 cycle power generating capacity instead of the former 72,000 kw of 60 cycle and 32,000 kw of 25 cycle capacity.

Company also proposes to concrete line a portion of the Canal Basin, Station 3B inlet and forebay. Thereafter, tunnel would be used for operation of Section 3A instead of the canal. These changes in operation necessitate also, pending further study, erection of a coffer dam across the lower end of the hydraulic canal to keep canal from filling with water, the company said.

Niagara Mohawk stated that it has not as yet made any determination respecting restoration of Sections 3B and 3C of Schoelkopf Station. Decision on this will depend on the outcome of engineering, geologic and other studies now under way.

Engines and altitude *continued*

available both on new engine installations as well as for many engines already installed and operating in the field.

In the past, engines have had to be derated in output at altitudes above 1500 ft compared to their maximum potential hp at sea level. Savings at 10 to 20% in fuel consumption are conservatively predicted for many types of power applications. With the greater adaptability to high altitudes, fewer engines will now be needed to meet power requirements. In addition, a predicted increase of 20 to 35% in engine hp will become available at no additional increase in cost per hp.

Four-cycle gas, diesel and gas-diesel engines, with C-B's turbocharging will pull their full loads at altitudes where men normally cannot exist without oxygen aid. It is reported that approximately a third of all engines built today involve operation at altitudes over 1500 ft above sea level.

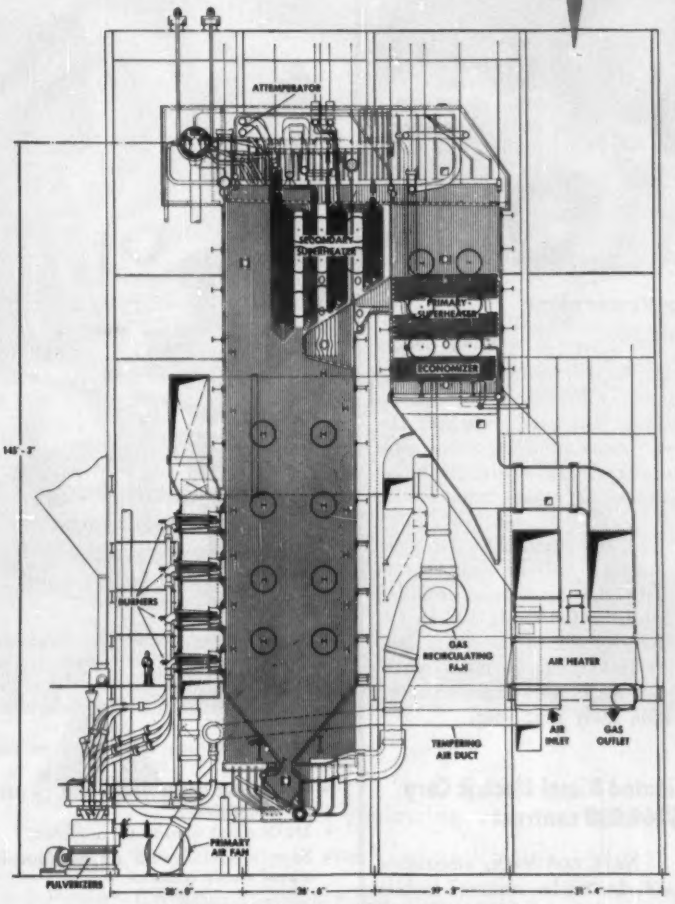
The former practice of derating engines from high altitudes resulted from

It's Vulcan Selective Sequence for Astoria Station's 2,400,000 lb./hr. Boiler!

Each of the two forty-foot furnaces firing Consolidated Edison's Boiler 30 at Astoria Generating Station will be equipped with a custom-designed Vulcan Selective-Sequence Soot Blowing System. The boiler now being built by Babcock & Wilcox is a radiant-reheat type to be fired by pulverized coal, oil or gas.

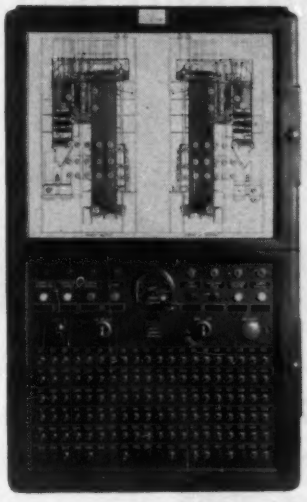
Drive for the soot blower systems will be electric; the blowing medium steam. Both Vulcan long retractable soot blowers and wall deslaggers are included in the system. Vulcan wall deslaggers maintain high striking power, keep thickness of deposits to a minimum.

Whether your boiler is large or small, power or process—a modern Vulcan Soot Blower System with automatic-sequential or selective-sequence control will keep it operating at peak efficiency. Your Copes-Vulcan representative has the ideas, information and experience to help you choose the system best suited to your needs.



CONSOLIDATED EDISON COMPANY
ASTORIA GENERATING STATION, NEW YORK, NEW YORK
BABCOCK & WILCOX TWIN-FURNACE BOILER
2—40′—0″ FURNACES

Capacity, Lb. Steam per Hour 2,400,000	Superheater Outlet Pressure, PSI..2,150
Design Pressure, PSI..... 2,500	High Pressure Steam Temp., F....1,050
Reheat Steam Temperature, F....1,000	



NERVE CENTER of the Selective-Sequence system is a completely pre-wired, factory-assembled controller for the soot blowers in each furnace. Selective Sequence lets operating personnel select proper blowing sequence for most effective boiler cleaning. Operator can tell at a glance which blowers are operating, time elapsed, number of blowers that have operated, and any malfunction of equipment or blowing medium.

COPES-VULCAN DIVISION
BLAW-KNOX COMPANY
ERIE 4, PENNSYLVANIA

50th Anniversary BLAW-KNOX 1906-1956

Check these features

Philadelphia spiral-bevel COOLING TOWER DRIVE

- √ Maximum Emciency . . . 97%-98% with minimum heat loss.
- √ Precision generated Spiral-Bevel Gears, case hardened for long service life.
- √ Heavy duty Housing construction.
- √ High dome permits mounting fan directly on unit, with ample clearance below fan blades.
- √ Oversize bearings insure trouble-free operation.
- √ Rugged . . . dependable . . . economical Reducer meets all AGMA standards.

These widely used Drives are made in six sizes, rated from 15 hp to 75 hp at 1750 rpm motor speed, with Ratios ranging from 2:1 to 9.2:1.

Catalog CT-53 available on request.

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INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID MIXERS • FLEXIBLE COUPLINGS

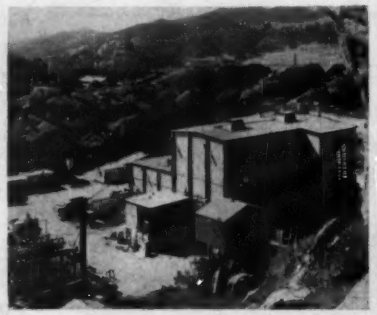
Virginia Gear & Machine Corp. • Lynchburg, Va.

REPORTS from the FIELD

Begins on page 162

inability of engines to breathe sufficient oxygen to burn all the fuel engine would take. Some auxiliary means has always been required to supplement loss of combustion air in rarefied atmospheres.

Although objectives of turbocharging engines have been known for years, the basic problem has been to evolve turbocharger characteristics that would efficiently compensate for lack of air.



Nuclear Power plant takes shape

► WORK IS WELL UNDERWAY by Atomics International, a division of North American Aviation, Inc, on the Sodium Reactor Experiment, a nuclear power plant which is part of AEC's program to develop economical power from atomic energy.

Heat from the reactor, in the background building, will be converted to electricity by generators being installed by the Southern California Edison Co.

The SRE, located in the Santa Susana Mountains about 30 miles northwest of Los Angeles, is expected to be in operation early next year.

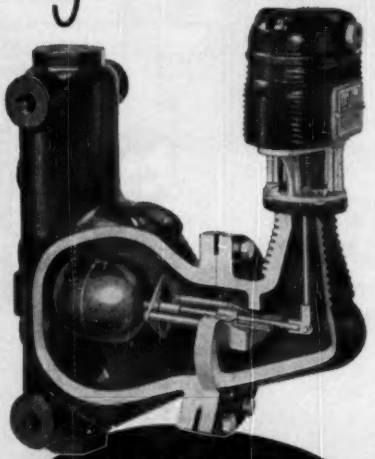
Consolidated Diesel Electric Corp given $264,000 contract

► A U.S. NAVY CONTRACT, amounting to $264,000, for trailer mounted mobile electric power plants for support of jet aircraft, has been awarded to Consolidated Diesel Electric Corp.

The units, Navy designation *NC-7*, are used to start jet aircraft and to supply power to test and maintain the aircraft's electronic systems, including radar, navigation and fire control. The NC-7 is a portable, gasoline driven generator set designed to supply power from 28-volt dc generators and one ac generator.

A unique feature of the generator set is an electric motor drive to the wheels to enable the operator to move the generator set simply by operating an electric switch.

McDonnell goes High Pressure



No. 92 Series
Pump Control, Cut-off and Alarm Switch
For pressures to 250 psi.

- Repulsion magnetic switching—for positive opening *and* closing.
- Unprecedented heat dissipation—okayed for 75° C. (167° F.) wiring at terminals.
- Extra generous clearances in float chamber.
- Operating levels unaffected by pressure changes.
- McDonnell quality throughout.
- Four models—with or without integral water column.

Use this new 92 Series for controlling boiler feed pump, or electric valves; for low water cut-off or alarm; for tank level control, etc. For lower pressures—to 150 psi.—use companion 91 Series. New catalog has full engineering data.

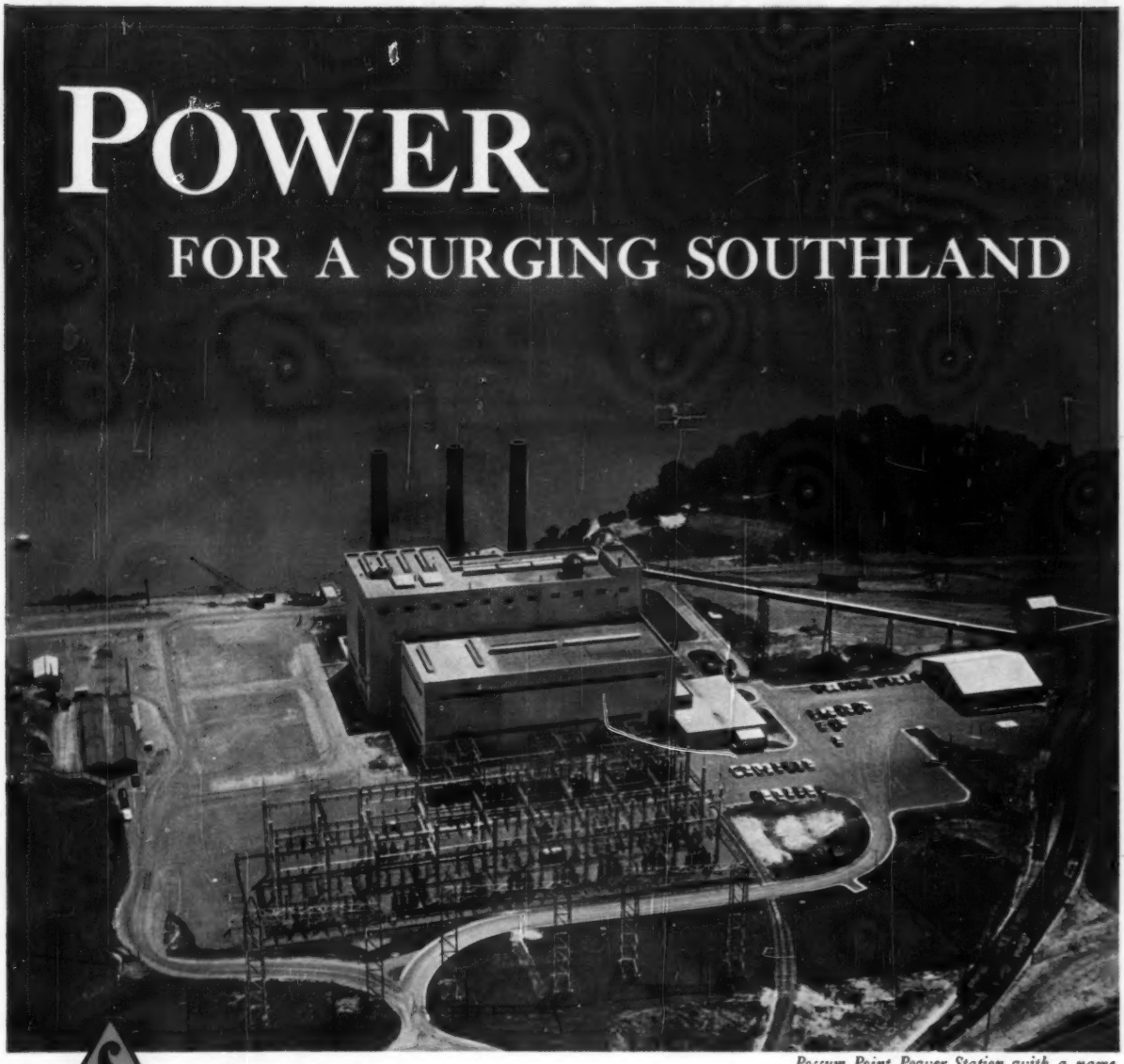
Write for Bulletin L-123

McDONNELL & MILLER, Inc.
3506 N. Spaulding Ave. • Chicago 18, Ill.

Doing One Thing Well

McDONNELL
Boiler Water Level Control

POWER
FOR A SURGING SOUTHLAND



Possum Point Power Station with a name plate capacity of 220,000 kw is located on the Potomac River near Quantico, Virginia

The third generating unit of the Possum Point Station of the Virginia Electric and Power Company – designed and built by Stone & Webster Engineering Corporation – went on the line in mid-1955, with a name plate rating of 100,000 kilowatts.

The Engineering Corporation is presently installing four 150,000 kilowatt units in three other generating stations being designed, constructed or extended for this client for commercial operation in 1957, 1958 and 1959.

These additional power facilities are examples of the forward looking steps being taken by Virginia Electric and Power Company to satisfy the rapidly expanding power requirements of the VEPCO system.

Write or call us for information as to how our experience can be of assistance to you.

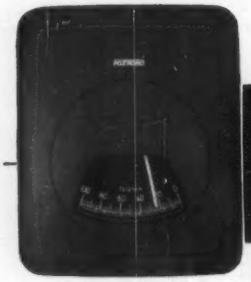
STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY of STONE & WEBSTER, INC.

New York Boston Chicago Pittsburgh Houston Los Angeles San Francisco Seattle Toronto

TELEMETERING

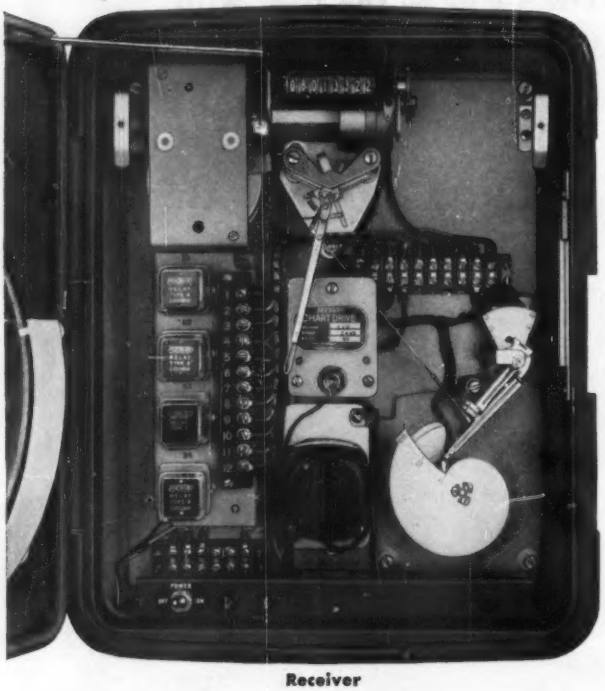
with unique new freedom from maintenance!



Transmitter

ANY TRANSMISSION SYSTEM

two wires
one wire and ground
radio or microwave
carrier current



Receiver

TELETAX by Foxboro

You can now get the full benefit of Foxboro accuracy and reliability for *remote* measurements, too! Teletax, the Foxboro impulse-duration system, brings new durability and simplicity to telemetering. For example, in the compact Teletax Receiver, dust-proof, plug-in relays and a husky reversing motor drive the recording pen positively. Maintenance is all but eliminated. And when servicing *is* necessary, *every* component is easily replaceable as a separate unit.

Teletax will transmit any measurement made with standard Foxboro measuring elements. Accuracy is ½% of full scale . . . regardless of normal variations in signal strength. Get full details on Teletax efficiency and economy. Write for Bulletin 17-11.

Most Practical System You Can Get!

RELIABLE: Thoroughly proved in actual field installations.

ECONOMICAL: Operates on lowest-cost transmission circuits.

LOW MAINTENANCE: A few drops of oil in the receiver motor every three months is all that's required; low 5 ma dc signal avoids failures.

Single or dual transmitter or receiver; indicating or recording; totalizing available.

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FOXBORO
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TELETAX
(impulse-duration) Telemetering

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

use steam efficiently, economically—choose the trap with . . .

just one moving part

. . . for easy maintenance

After all, a steam trap *should* be simple. Its job of discharging condensate and air from steam lines and equipment, is a simple one. But its importance shouldn't be overlooked. On its effectiveness can rest your economical use of steam . . . the efficiency of your process operations.

With Nicholson steam traps there's just one moving part. Nothing to go wrong. But with all their simplicity, Nicholson traps have the greatest capacity of any trap their size. Plenty of other important features, too, and it'll be well worth your while to check them.

- **Powerful valve action**
- **Tight, positive shutoff**
- **No dribbling, no steam waste**
- **Each unit service tested**

Specify Nicholson, and be sure.

Write today for new Bulletin 10-55

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TRAPS • VALVES • FLOATS • METAL PARTITIONS
LAUNDRY, DRY CLEANING AND PRESSING MACHINERY

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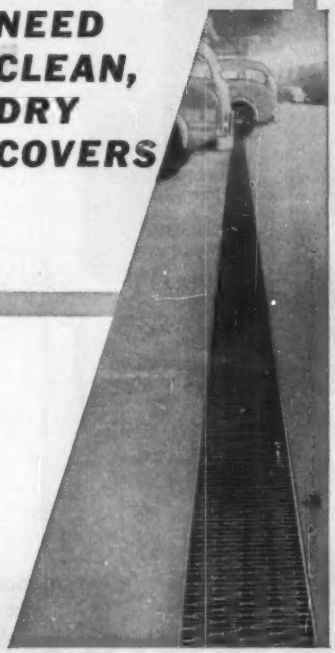
Plant Trenches NEED CLEAN, DRY COVERS



TRENCHES in floors of industrial plants often house subsurface pipes, valves, etc. Often these trenches are covered with cast iron plates or wooden boards which collect grease, oil or water, making unsafe floor areas.

Trench covers of 75% open Irving metal grating remain safe because they will not collect these substances. In addition to providing drainage and traction, grating sections can be easily removed for access to trenches.

★

Manufacturers of Riveted, Pressure-Locked and Welded Gratings in Steel, Aluminum and other metals for over 50 years.

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More TECHNICAL BRIEFS

Begins on page 164

be satisfactorily operated at higher temperatures with the sealed construction.

The advent of the sealed-transformer expanded the application of the dry-type into areas where excessive moisture or corrosive conditions existed. It practically eliminated maintenance. Use, however, is still restricted to areas of low sixty-cycle and impulse-voltage requirements. *AIEE paper No. 56-61.*

A study of models for use in evaluating dry-type transformer insulating systems. *By T R Walters and A L Scheideler, General Electric Co.*

A working group of the AIEE Transformer Committee has been working for several years to establish a functional aging-test for dry-type transformers. It is the purpose of this paper to describe the part played by the General Electric Transformer Division in cooperatively developing the required test procedures and to determine the suitability of the proposed model. *AIEE paper No. 56-29.*

Area effect and its extremal basis for the electric breakdown of transformer oil. *By K H Weber and H S Endicott, General Electric Company.*

Large high-voltage transformers have oil as the major electrical-insulation component. Because of this and other critical uses of oil in various electrical apparatus, a more complete understanding of oil breakdown is of immediate, practical importance in securing optimum use of the oil. To achieve this goal, dielectric strength tests can be made on each specific design or configuration of insulating components for the entire range of oil quality encountered in practice, but this would be a formidable task. It would be a forward step to be able to base design on the results of simple, small-scale oil breakdown tests. Doing so, requires knowing the effect of electrode sizes, shapes, configurations, test and operating conditions on oil breakdown. *AIEE paper No. 56-139.*

Effects of insulation thickness on the aging of organic insulation in air. *By L C Whitman and A L Scheideler, General Electric Company.*

Organic insulations composed of paper or cloth base with phenolic or black-asphaltic varnish impregnant are shown by extensive tests to have an aging rate in air dependent on the insulation thickness. A change in insulation thickness from that representative

Directions for ordering papers on p 244

The Greater the Pressure... the Tighter It Holds!

There's still nothing simpler or more efficient in power line service than this Wilcox Self-Sealing Gasket which has served industry so well over the years. The U-shaped metal outer cover is packed with a resilient filling (usually rubber or asbestos). Pressure exerted on this elastic filling forces it into the cover, putting force against the adjacent flange surfaces. Thus, internal pressure that tends to blow ordinary gaskets makes the Wilcox Gasket tighter in the joint. Available with covers of copper, lead, tin, aluminum, monel, stainless steel, etc. in all sizes—standard or special.

Write for details and quotations

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Chicago 19, Ill.

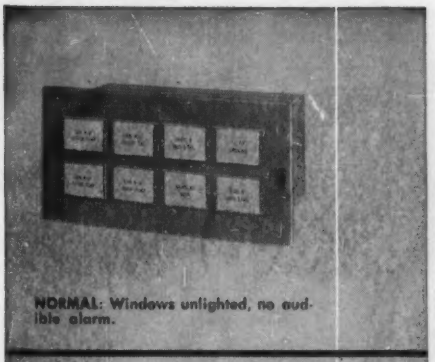
Building or Expanding?

THINK of
SAFETY
CONVENIENCE
ECONOMY
THINK of

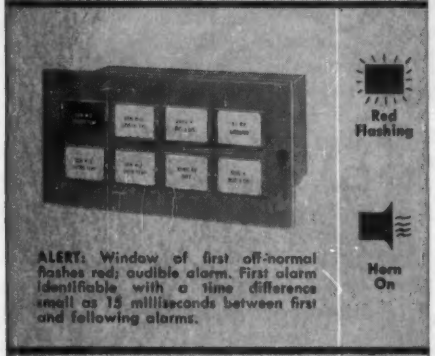
Babbitt
Adjustable
SPROCKET RIM
with Chain Guide

- Simplifies pipe lay-out
- Fits any size valve wheel
- Easy to install and operate
- Operates any valve from plant floor
- Time and money saving fixture
- No maintenance; first cost only cost
- Packed, completely assembled, one to a carton
- Hot galvanized, rust-proof chain available for all sizes
- Easy to follow instructions with each unit
- Your supplier carries complete stocks
- Write for new descriptive catalog sheet and prices

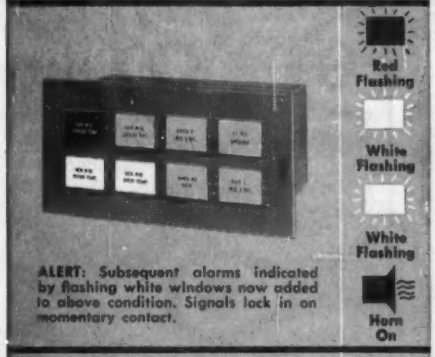
Babbitt STEAM SPECIALTY CO
2 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.



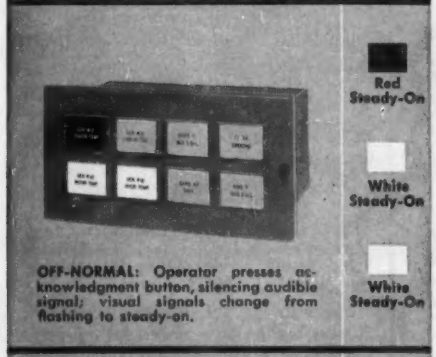
NORMAL: Windows unlighted, no audible alarm.



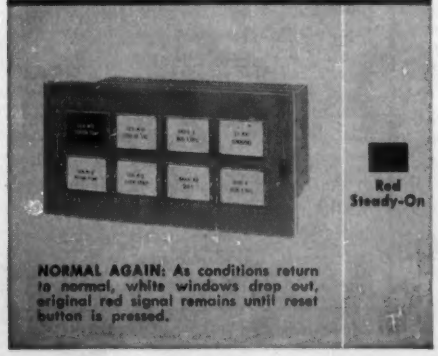
ALERT: Window of first off-normal flashes red; audible alarm. First alarm identifiable with a time difference small as 15 milliseconds between first and following alarms.



ALERT: Subsequent alarms indicated by flashing white windows now added to above condition. Signals lock in on momentary contact.



OFF-NORMAL: Operator presses acknowledgment button, silencing audible signal; visual signals change from flashing to steady-on.



NORMAL AGAIN: As conditions return to normal, white windows drop out, original red signal remains until reset button is pressed.

Panalarm "VS" Annunciator identifies first off-normal from subsequent alarms for rapid corrective action

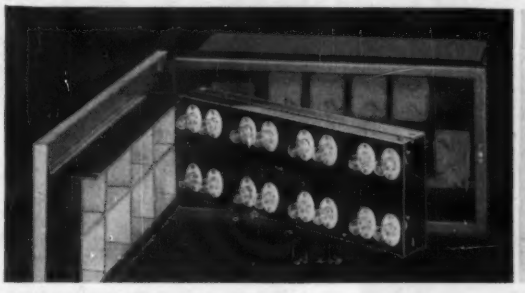
You gain the control advantages of an audio-visual information system, not just an alarm system, with the Panalarm "50VS" Visual Sequence Annunciator. This is particularly valuable when one off-normal condition will cause a "chain-reaction" of off-normals. Typical Panalarm applications are found in the process industries and among users of automatic machinery.

The original off-normal is clearly identified, enabling the operator to take immediate, corrective action. A considerable saving in down-time can often be effected simply by knowing the original source of trouble.

Panalarm "50VS" is completely flexible in setting up various sequential groups. Any number or combination of signals may be grouped as an independent sequence, and the groupings may be changed at any time by simple jumpers on the terminal block. Signals may be either illuminated nameplate or bullseye indicators, combined with a horn, bell or other audible signal. Signaling is simple and positive. A typical sequence is illustrated on the left.

Write for literature on the "50VS" and other Panalarm Annunciator Systems. A Panellit sales engineer will be happy to make a survey of your production operation to determine whether a Panalarm system can help increase efficiency and safety in your plant.

All Panalarm Annunciator Systems are completely modular, permitting future growth and changes. The photographs below illustrate a typical Panalarm Cabinet with illuminated nameplates and the hermetically sealed Panalarm "50" plug-in relay unit. Components throughout are ruggedly built to instrument standards for continuous, dependable duty. Entire Panalarm system is suitable for Class 1, Division 2 installations.



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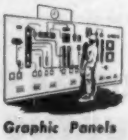
Engineered Information Systems for Industry

Panalog Information Systems



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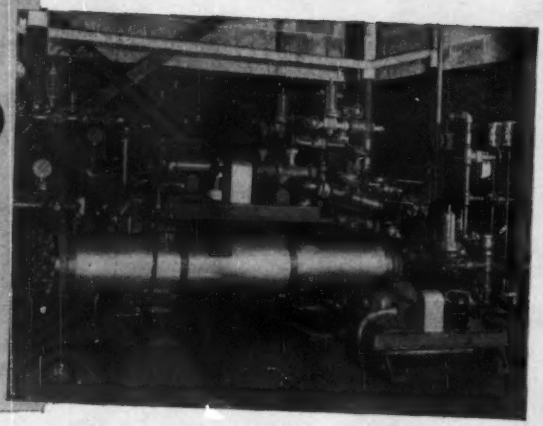
2 ENCO FUEL OIL UNITS *in this plant*



Here is a typical 2 unit installation of Enco fuel oil pump sets—selected to take care of all the requirements of a building materials manufacturer.

The Large Unit has 2 pumps and 2 heaters, completely automatic and arranged for operation with either heater, or either pump—or both. With one heater and pump the capacity is 11 gpm Bunker C oil at 300 psig pressure, and temperature rise from 90F to 230F.

The Small Unit is for cold starting up—has no heater. The capacity is 3 gpm of No. 2 oil at 300 psig pressure.

All Enco sets are individually designed, each for specific plant conditions—for easy installation, low maintenance and minimum carefree operation.

Complete details including the 10 important features of Enco fuel oil heating and pumping sets are given in Bulletin OB53. Copies gladly sent upon request.

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MURCO

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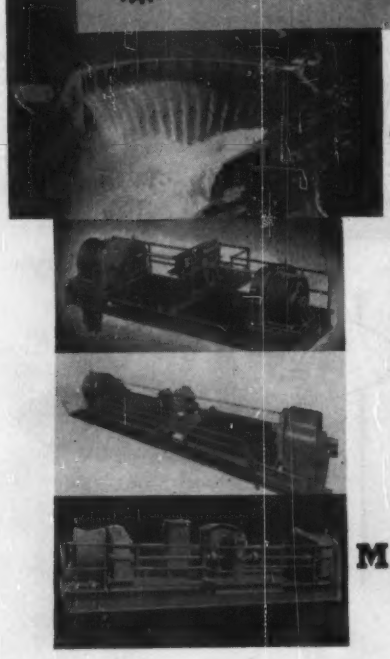
for any Size Power Dam....



MURCO Gate Hoists are designed and built in a wide range of capacities—for any size power dam—from less than one ton to over 100 tons . . . from the smallest hand operated to the largest motor operated gate hoist. Back of every MURCO Gate Hoist is over 70 years of designing and building, and from this experience we have accumulated designs and patterns that may fit your requirements. In planning gate hoists we suggest you write us before your plans for the project as a whole are completed.

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More TECHNICAL BRIEFS

Begins on page 164

of turn insulation to that used for a major voltage barrier may increase its useful life in air by as much as ten times if in a dry atmosphere. The corresponding change in temperature class for a specific number of hours of life in air may be of the order of 30 to 50 C for this change in thickness, under the same favorable conditions.

A possible explanation of this difference is offered, based on the progressive shielding of the inner laminae by the outer portions, giving the effect of the shielded portions operating in a non-oxidizing medium. The inhibition of evaporation effects may also be a factor. *AIEE paper No. 56-157.*

Application of a digital computer to the design of power transformers to specification. *By C L Moore, W T Duboc and P A Zaphyr, Westinghouse Electric Corporation.*

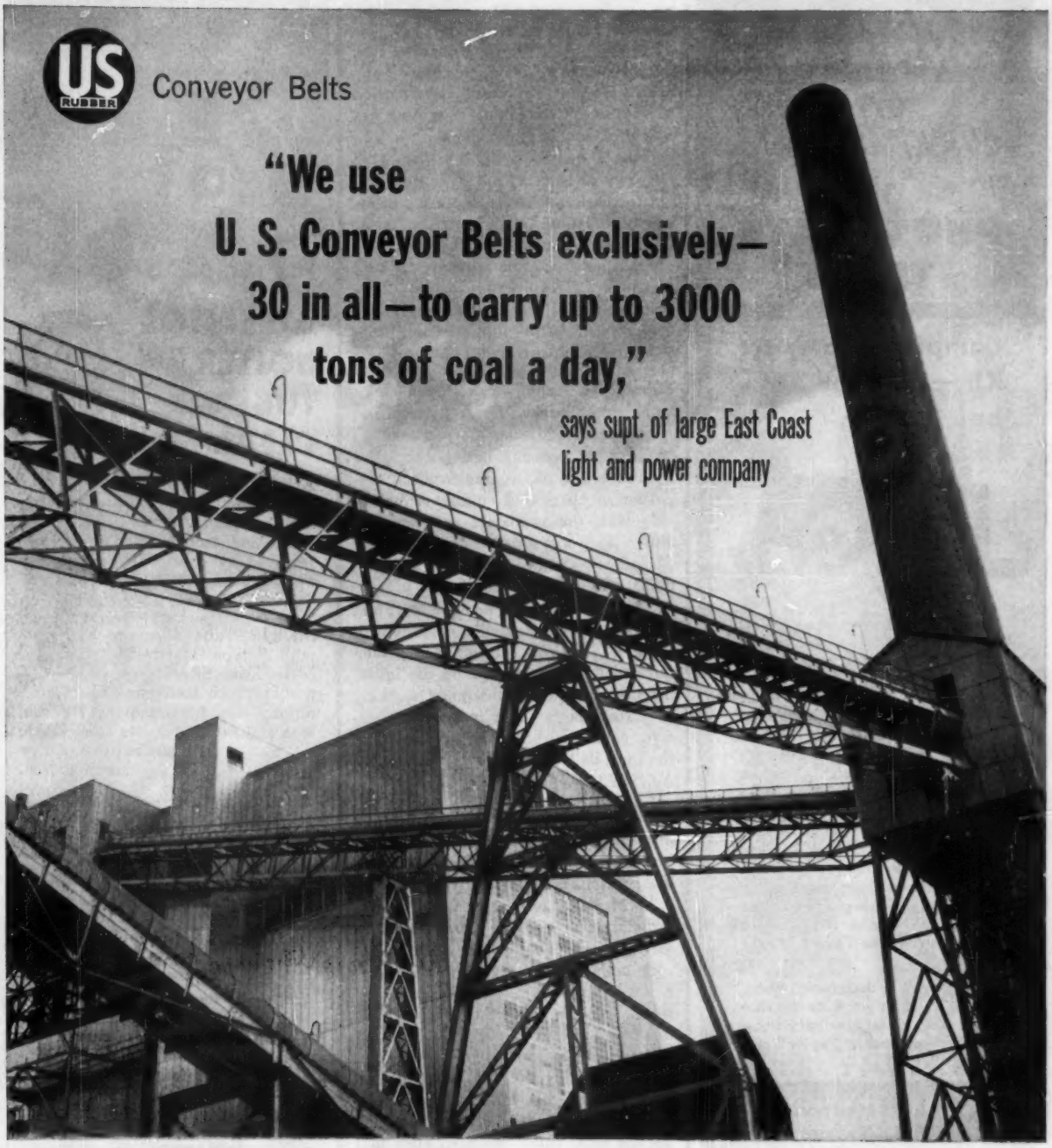
Most power transformers of 1000 kva and larger are built to specification. The problem of reducing the time required to produce designs for them has been acute for many years. In the early part of 1954, this problem became the focus of attention due to increasingly critical performance requirements that actually lengthened the design time required while demands for shorter building cycles were becoming more and more pressing. Furthermore, developments in core steel and insulation increased the need for comprehensive studies of the effects of these improved materials on the economics of transformer design and construction. Such studies can be made on a theoretical basis.

One answer to the problem of reduction in design time seemed to lie in the possibility of programming a digital computer to produce designs with no more input than the specifications normally given a design engineer. The growing availability of such machines made an investigation of this possibility feasible. *AIEE paper No. 56-79.*

A new technology of insulating oils of petroleum origin. *By F C Doble, Doble Engineering Company.*

A new technology of insulating oils of petroleum origin has evolved from theories based on a long-time study of oils under power-system operating service conditions. This study has resulted in the concept, recently published, that insulating oils when properly serviced and treated with additives can be given practically unlimited extension of useful life, free from sludge or excessive

Directions for ordering papers on p 244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Conveyor Belts
"We use
U. S. Conveyor Belts exclusively—
30 in all—to carry up to 3000
tons of coal a day,"
says supt. of large East Coast
light and power company

The giant generating plant of this large New England light and power company, furnishes enough electric power for a city of 165,000 people. Thirty "U.S." Conveyor belts carry the 3000 tons of fuel in a round-the-clock operation.

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That's the story everywhere. High-volume operators are using "U.S." Belting, and the result is always *lower costs.* Like so many other successful belting installations, the system in this light and power plant is the result of United States Rubber's "Three-Way Engineering"—in which "U.S." engineers work with the engineers of the conveyor builders and engineers of the power company to turn out the best belt conveyor system for the specific job.

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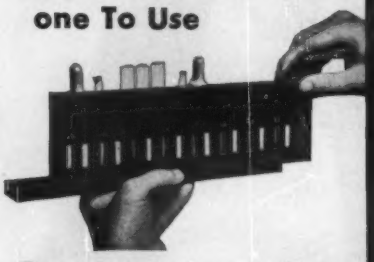

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More TECHNICAL BRIEFS

Begins on page 164

acidity due to oxidation. An extension of the study to refining processes has now led to new practical theories concerning the structure of oil and the behavior of some of its basic constituents. Accelerated tests that are a measure of the quality of an oil in terms of useful operating life characteristics are an indispensable tool in the new technology. This paper outlines these theories and their application to the requirements of the insulating oil problem. *AIEE paper No. 56-141.*

Unbalanced open-wye open-delta transformer banks. *By J C Neupauer, Westinghouse Electric Corporation.*

Three-phase loads can be supplied by two single-phase transformers connected in open-delta on the secondary side with the primaries connected in either open-wye or in open-delta. Installations in which service factors, duty cycles or overmotoring provide some margin in the nameplate rating of motors are particularly suited to these transformer connections. Economies that can be realized in the initial installation and in subsequent stocking of transformers often make the open-wye connection more attractive than the open-delta connection. *AIEE paper No. 56-181.*

Controlled temperature and insulation protection in the operation of power transformers. *By J A Klingensmith, Westinghouse Electric Corporation.*

In May 1943, fourteen small power transformers were built and placed in service. These units were identical in core and coil construction with large power-type production units in all respects except size. They differed in the type of protection provided for the oil. This protection varied from free breathing—no protection, to sealed inert gas with oil filter. Two reports have been published on these units under the same title. The first, after four years of service, was presented in June 1949 as *AIEE Paper 49-193.* The second, after eight years of service, was presented in January 1952 as *AIEE Paper 52-88.* This report reviews the data accumulated since the last report and attempts to indicate amount of life expended under the test-loading conditions. *AIEE paper No. 56-89.*

Leakage reactance of transformers. *By Andrew A Halacsy, Jeffries Transformer Company.*

Published methods of the calculation of the leakage-reactance of transform-

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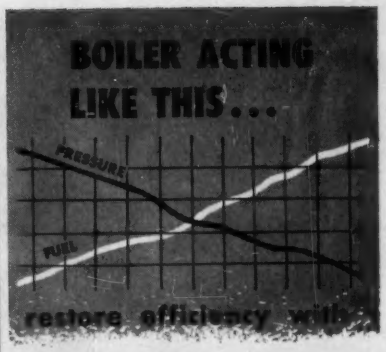

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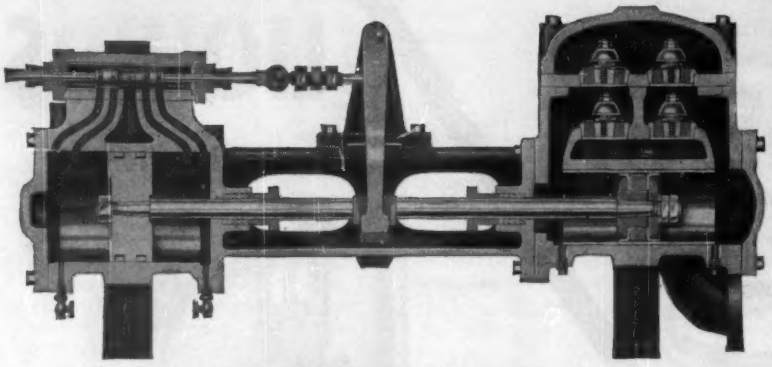

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More TECHNICAL BRIEFS

Begins on page 164

ers are either too complex or inaccurate for practical use. This paper presents a method which is simple and sufficiently accurate for practical purposes. Numerous test results confirm its validity. *AIEE paper No. 56-90.*

Corrosion

The relation of thin films to corrosion. *By T N Rhodin.*

Oxide films on stainless steels have been classified into three types according to film thickness, film structure, film composition and influence of film on resistance to corrosion.

Compositional properties of oxide films isolated from surface of stainless steels have been studied using specially developed microanalytical techniques. Properties of passive films on stainless steel have been evaluated and effects of alloy composition and surface treatment on other types of films on *Types 304, 316* and *347* stainless steels have been studied.

Finally, influence of corrosion in various media had been correlated with film compositional properties. Composition of films after immersion in acids was found to be related to film composition prior to immersion. Effect of immersion depended on the nature and intensity of corrosion and was reflected most sensitively by the iron and silicone contents of the films.

Conclusion made is that film properties strongly indicate the capacity of austenitic stainless alloys to develop corrosion-resistant surfaces in certain environments. *NACE paper No. 42.*

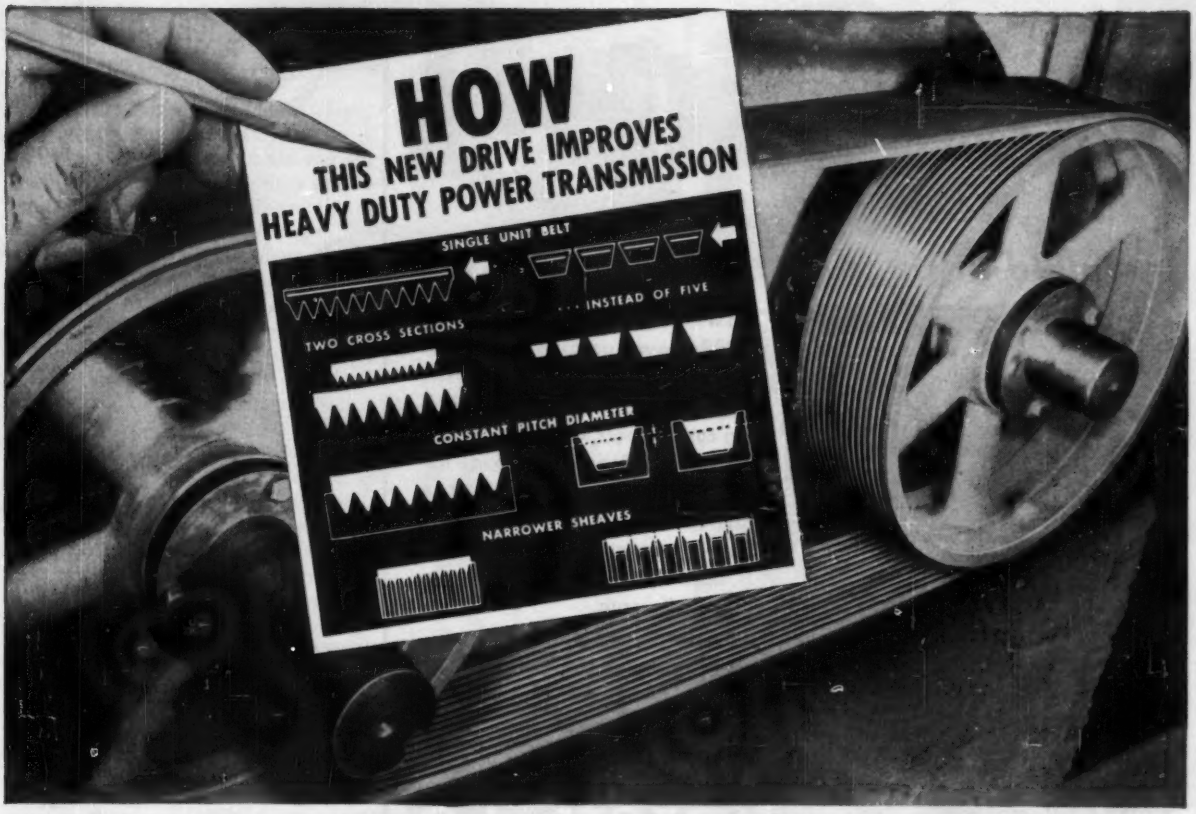
Collection and correlation of high-temperature, hydrogen sulfide corrosion data. *By G Sorell and W B Hoyt.*

Corrosion by gas mixtures containing hydrogen sulfide at elevated temperatures is reviewed, with particular emphasis types of environments present in catalytic reforming and desulferizing units of petroleum refineries. Data compiled from published literature, laboratory, pilot plant and refinery experiences are correlated and summarized.

Within the general limits of conditions existing in these types of units, corrosion rates are shown to depend primarily on temperature and hydrogen sulfide partial pressure.

Corrosion resistance of carbon steel and chrome-moly alloy steels is approximately equal; the 12 percent chrome stainless steels may offer slight im-

Directions for ordering papers on page 244



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Unique design accounts for the unusual power capacity of R/M Poly-V Drive. A *single, endless* belt with parallel V-ribs runs on sheaves specially designed to mate precisely with the belt ribs. The uniform pull of this single unit belt distributes drive load evenly over the full width of the sheave . . . gives higher horsepower capacity per inch of drive width than ever before possible.

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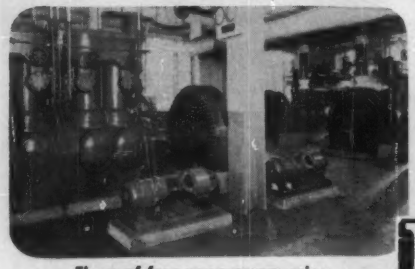

Three of four compressors using 1800 horsepower

Dow Brewery, established in 1790, now has a yearly output of over 1½ million barrels. Frick refrigerating equipment, including compressors, condensers, brine coolers, and carbon-dioxide liquefying system, was selected for an important expansion modernization program. Installation by J. H. Lock & Sons, Ltd., Frick Distributors in Toronto.

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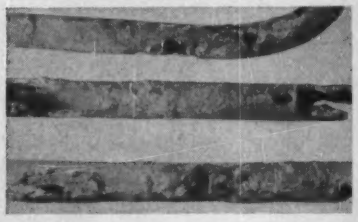
CORROSION PROBLEMS?



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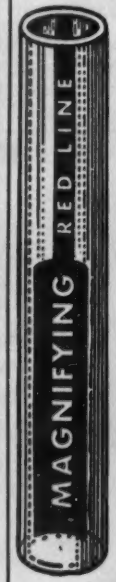

FIG. 22 SERIES 750

FIG. 21 LIP-MOLD

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More TECHNICAL BRIEFS

Begins on page 164

provement but their degree of resistance is erratic. The 18 percent chrome, 8 percent nickel stainless steels have excellent resistance except for the most severe conditions. Aluminum coatings are practically immune to hydrogen sulfide attack, however, there is insufficient experience to evaluate their permanence in service.

The nature of hydrogen sulfide attack and the relative importance of applicable factors is discussed. *NACE paper No. 52.*

Effects of velocity on corrosion. *By H R Copson.*

Velocity can be a major factor in corrosion of metals. Like most factors influencing corrosion, effects of velocity are varied and sometimes appear conflicting. Increased movement of the environment past a metal part usually increases corrosion by supplying the corrosives at a faster rate. Corrosives can reach the metal surface more readily because motion thins or removes any quiescent layers at the metal surface. On the other hand uniform motion may be beneficial because it makes exposure conditions more uniform, may prevent local attack and pitting. Some motion is definitely beneficial if inhibitors are present. In extreme cases high velocity may induce passivity and stop all corrosion. The more damaging effects of velocity are often due to turbulence. Turbulence may set up differential-aeration cells and metal-ion cells which lead to rapid local attack and may form anodic areas by eroding away thin protection films, in which case the attack is called erosion-corrosion. A high ratio of cathodic area to anodic area increases penetration rate in these cases. Velocity effects vary on different metals and accordingly the galvanic behavior of couples may be changed greatly. Actual erosion of metal can be caused by very high velocities, particularly if solids are present. Related to velocity effects is the damage caused by cavitation-erosion. Examples are given illustrating all these types of attack. *NACE paper No. 64.*

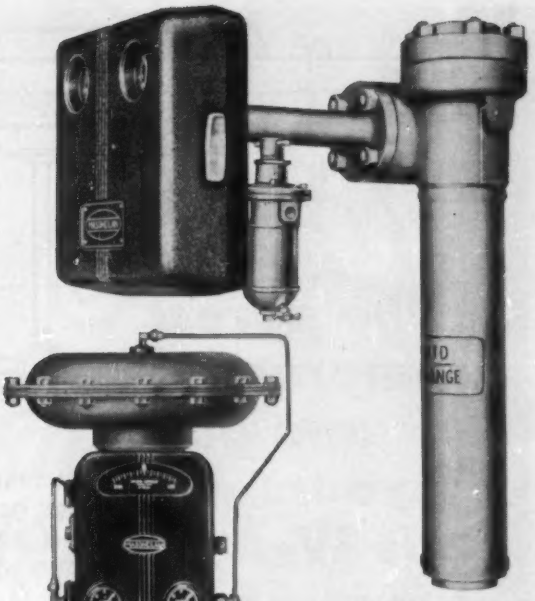
Corrosion by low-pressure geothermal steam. *By T Marshall and A J Hugill.*

Corrosion tests in geothermal steam contaminated with chlorides, hydrogen sulfide and carbon dioxide are described and detailed results are given for a range of common engineering alloys.

Most engineering alloys proved mod-

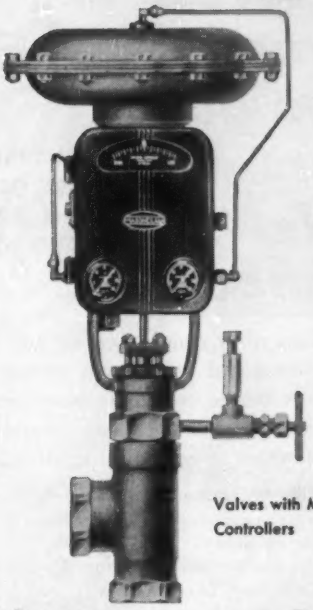
Directions for ordering papers on p 244

Indicating, Recording and Non-indicating Controllers



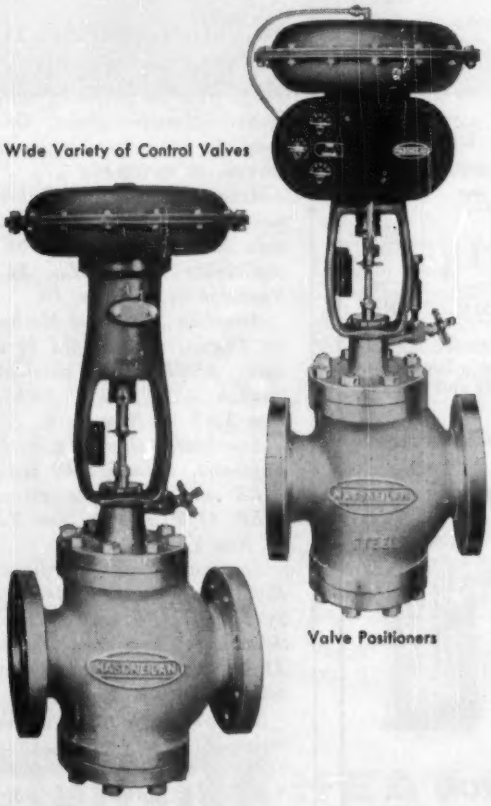
Liquid Level Controllers

Differential Pressure Transmitters



Valves with Mounted Pressure Controllers

Wide Variety of Control Valves



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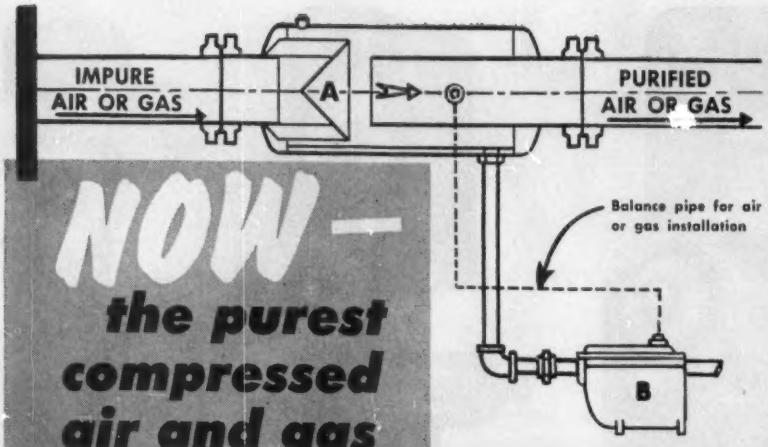

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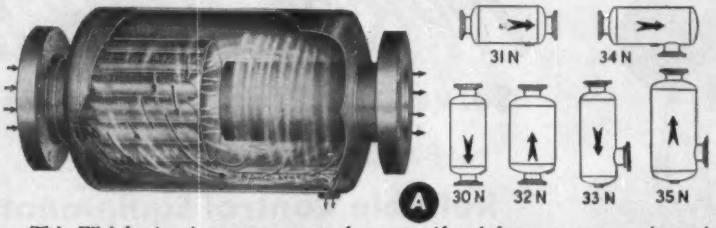
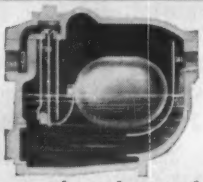
—oil and water on compressed air service at outlet of inter-cooler and after-cooler equipment.
—oil, moisture and tar between stages in coke oven gas compressors
—oil and water from CO_2 gas lines
—oil and water from hydro-carbon lines
—entrainment from vapor lines following evaporation



This Wright-Austin separator employs centrifugal force to remove impurities from steam, air or gas flow. The pressure drop is extremely low. Type 31N, as well as other models shown, is light weight, compact and sturdily constructed according to ASME code.



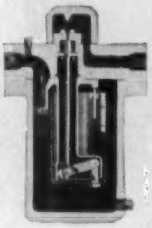
23-AC TRAP (0-125 PSIG)

Separated condensate flows to trap. Drainage is automatic. Particularly adapted where cold, gummy, emulsified cylinder lubricants make ordinary traps inoperative.

B

101-AC TRAP (0-600 PSIG)

Cast steel body, cover and bonnet. Designed for draining condensate where high pressures are involved. Internal mechanism all attached to cover for easy service.



WRIGHT-AUSTIN COMPANY
1894
3245 WIGHT STREET • DETROIT 7, MICH.

WRITE FOR NEW CIRCULAR 506-A

More TECHNICAL BRIEFS

Begins on page 164

erately susceptible to steam corrosion. Titanium and austenitic stainless steels (especially molybdenum-bearing varieties) were highly resistant. Stress-corrosion cracking occurred in hardened 13 Cr stainless steel, hardened low-alloy steels, one grade of austenitic stainless steel and aluminum bronze.

Physical and chemical factors influencing corrosion by the geothermal steam are discussed. *NACE paper No. 60.*

Work measurement as applied to industrial painting. *By B C Wright.*

Production of paint crews vary with material, location, weather, morale and other factors. Consequently, it is difficult to know when a full day's work is obtained. This paper explains the application of three types of work measurement: (1) daily square footage and man hour reports (2) motion picture studies (3) work sampling. Results are included for a particular job but sufficient details are given to permit the reader to apply work measurement on his job and thereby increase production. *NACE paper No. 54.*

TO OBTAIN COMPLETE TEXT

Material for these abstracts comes from the following sources unless otherwise stated. Order complete paper from source, not POWER.

American Society of Lubrication Engineers, identified by initials ASLE. Information as to availability from ASLE, 84 E Randolph St, Chicago, Ill.

American Society of Mechanical Engineers. Identified by initials ASME and obtainable through ASME, 29 W 39th St, New York 18, New York.

American Institute of Electrical Engineers. Identified by initials AIEE and obtainable through AIEE, 33 W 39th St, New York 18, New York.

American Power Conference, 18th annual meeting. Identified by initials APC and obtainable through purchase from Director, APC, Illinois Institute of Technology, Chicago 16, Ill.

National Association of Corrosion Engineers, 12th Annual Conference. Identified by initials NACE. For further information contact NACE, 1061 M & M Building, Houston 2, Texas.

. . . there's enough difference to make ALL the difference

Every single finished Scovill Heat Exchanger Tube is subjected to a 1,000-lb. hydrostatic pressure test and an 80-lb. air pressure test under the eyes of experienced inspectors. Very seldom does a tube fail at this point; yet this and other final inspections for tube perfection are always rigidly maintained.

Before Scovill Heat Exchanger Tubes reach these final inspection benches, specialized production methods and controls have already assured their inherent uniformity in alloy composition . . . with soundness in metal structure . . . and dense, smooth surfaces, free from defects. Scovill safeguards assure delivery to customers of tubes in top physical condition . . . an essential to dependable heat exchanger service.

Scovill Technical Service stands ready to help you select the correct tube alloys for your applications, with recommendations based on most comprehensive experience records.

Scovill Manufacturing Company, Mill Products Division,
99 Mill Street, Waterbury 20, Connecticut. Phone: Plaza 4-1171.

SCOVILL

HEAT EXCHANGER TUBE

FOR APPLICATIONS FROM MARINE TO PETROCHEMICAL . . . FROM COMPRESSOR INTERCOOLERS TO "CAT-CRACKER" EXCHANGERS.

Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Naval Brass • Red Brass, 85% • Deoxidized Copper
Arsenical Copper • Cupro Nickel 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

115C36

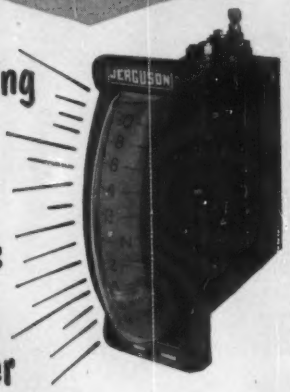
Here's Jerguson's

New!

RED FLASHER TRUSCALE

Remote Reading Liquid Level Gage

Flashing Red Scale Warns of Danger



Jerguson Truscales are now available with a unique new safety feature. Illuminated scale starts flashing red if boiler water level gets too high or too low. This positive warning flashes continuously until the dangerous condition is corrected.

Truscales offer the greatest possible protection for expensive equipment. They give instant remote reading of liquid level of boilers, tanks, etc., with the amazing accuracy of ½ of 1% of scale reading. Convex face, with scale markings directly on it, gives 180° visibility. It's easy to take readings from any point from which the face can be seen.

Protect valuable equipment with Jerguson Truscale Remote Reading Gages. Send for new 8-page bulletin which gives complete details.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Fellsway, Somerville 45, Mass.

Offices in Major Cities

Bailey Meters & Controls, Ltd., London, Eng.
Controle Bailey, Paris, France

APPOINTMENTS

Corporation executive changes

Preferred Utilities Manufacturing Corp: J S Kaplan, president; G W Bohn, chairman of the board; W H Bohn, vice-president. **Reliance Electric & Engineering Co:** Edward E Helm, president; James W Corey, chairman of the board. **Worthington Corporation,** Mason-Neilan division: F Kenneth Morrison, president and general manager. **Sparks Withington Company:** Robert D Flori, president of new combination of Flori Pipe Company and The Houston Pipe & Steel Company.

Borg-Warner Corp: Stanley J Roush, group vice-president; G W Kelch, president of recently acquired Ingersoll-Humphryes division. **Phoenix Manufacturing Company:** John W Gosselin, executive vice-president. **National Research Corporation:** S Sydney Minault, vice-president. **Magnetrol, Inc:** B L Binford, vice-president, manufacturing.

Operation executive changes

Olin Mathieson Chemical Corporation: Edward Hartshorne, general manager of nuclear fuel division. **United States Rubber Co:** Arthur E Benson, development manager of international division. **Baldwin-Hill Company:** John L Mohun, general manager of manufacturing. **Atomic International,** division of North American Aviation, Inc: J F Trevillyan, project manager for company's laboratory reactor; George V Alevizon, project manager for organic moderated reactor experiment. **Norton Company:** Theodore J Englund, manager of industrial engineering; Paul L Lantz, ass't manager of industrial engineering; William F Watts, factory manager of refractories division.

Engineer changes

Conoflow Corporation: Albert J Hanssen, chief engineer. **Republic Aviation Corporation:** Robert L Bortner, chief engineer for administration. **General Electric Co,** Foundry dept: James K Sprinkle, applied research engineer with applied research and development laboratory. **The Cooper-Bessemer Corporation:** J P Matthews, turbocharger application engineer. **Beckman Instruments, Inc,** Spinco division: Ralph S White, manager of research and engineering. **Brooks Rotameter Company:** Robert F Gilman, production engineer.

New sales vice-presidents

Pacific Pumps, Inc: A F Canada, centrifugal pumps division. **H K Por-**

STICKLE *Open Float* STEAM TRAPS

FOR EVERY TYPE SERVICE

No Levers! No Toggles! No Hinges! No Diaphragms!

There's a Stickle open float steam trap for every service . . . for every pressure and vacuum. Capacity range: 500 to 46,000 lbs. per hr. Simple, positive operation automatically regrinds valve and valve seat. Air and gases discharge with condensate. Many still operating after 44 years of continuous service.

SERIES 100 TRAPS (Shown Above)
For drainage of smaller processing units operating at low, medium or high pressures. Internal strainer. Capacity range: 500 to 3,000 lbs. per hr. For straight-in-line installation. Write for Bulletin 115.

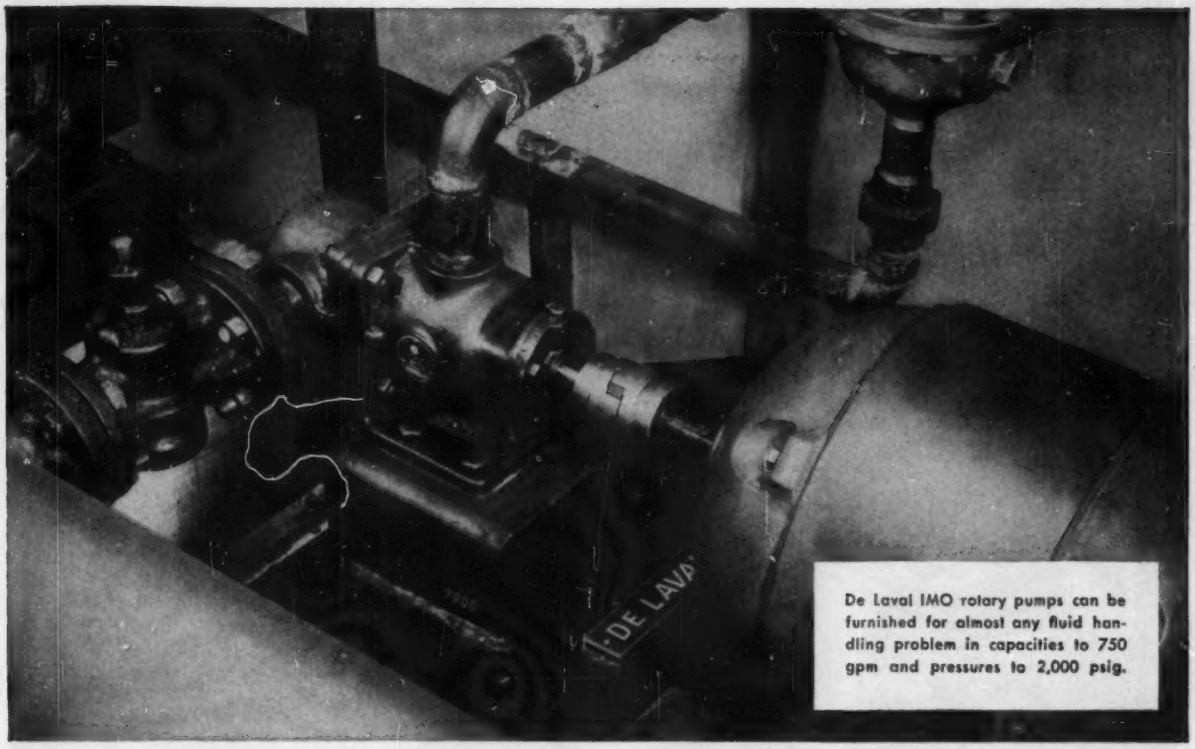
SERIES AE TRAPS
For drainage of larger units operating at medium and high pressures. Capacity range: 5,000 to 20,000 lbs. per hr. Write for Bulletin 315.

SERIES 50 TRAPS
For drainage of units operating at medium and high pressures. Capacity range: 18,000 to 46,000 lbs. per hr. Write for Bulletin 515.

STICKLE STEAM SPECIALTIES CO.
2265 Valley Ave. • Indianapolis 18, Ind.

Specialists in Reducing the Cost of Steam—Since 1905

Stickle Equipment
Cuts the cost of steam



De Laval IMO rotary pumps can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 2,000 psig.

What to Look for in a Rotary Screw Type Pump

By W. J. MONGON, *Assistant Chief Engineer*
De Laval Steam Turbine Company

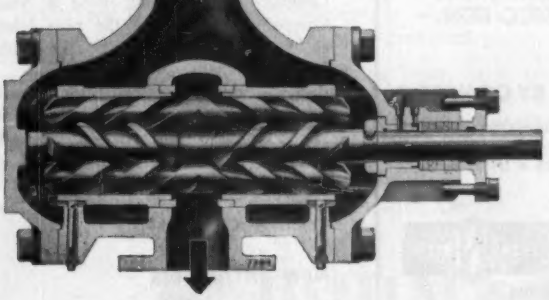
A sound knowledge of design, and how it affects performance, is the best insurance a buyer can have that he will get the pump he needs. This brief analysis of the IMO, a rotary three-screw pump manufactured by the De Laval Steam Turbine Company, will give you some of the necessary facts.

What qualities should you look for in a rotary type pump? It must, of course, meet specified capacities and pressures. But, it must also be efficient, operate quietly, stay on the job.

The axial flow of a screw type pump, and the resulting low inlet losses for any given pump speed, are important benefits that should be considered in making pump selections. The absence of timing gears and other mechanical features of construction also enable the De Laval IMO pump to operate at direct-connected motor and turbine speeds . . . to handle viscous liquids and high suction lifts.

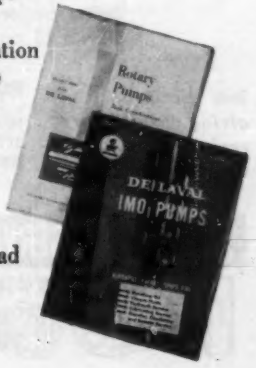
One of the most important features of the IMO pump is the hydraulic turning of the idler or sealing rotors. The central or power rotor is the pumping element; the liquid pumped turns the sealing rotors.

A screw type pump is well suited for applications where pulsation-free flow is desirable. The axial flow of the liquid without trapping and the unique thread form which keeps closures fluid-tight contribute to quiet operation of the IMO pump.



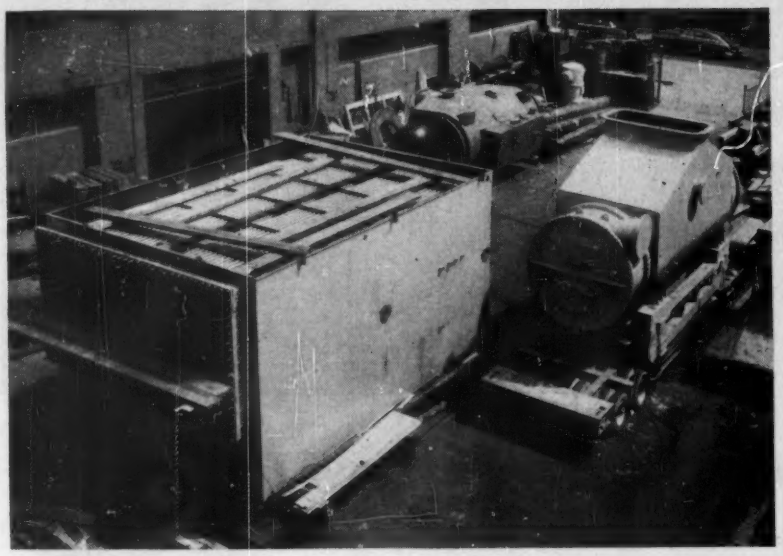
This is a cross-section of the De Laval IMO Series A322A, a positive displacement rotary screw type pump.

Catalog LS gives useful application and specification data on the IMO pump. An article titled, *Rotary Pumps, Basic Considerations in Their Application*, contains a description of rotary pumps in general. For these publications, write on your company letterhead to De Laval Steam Turbine Company, 815 Nottingham Way, Trenton 2, New Jersey. DL-301



Two more cities select··

CONSECO CONDENSERS



- **CITY OF DETROIT, MICHIGAN**
  One 27,500 sq. ft. condenser
- **CITY OF WASHINGTON, INDIANA**
  Two 8,500 sq. ft. condensers

This recent photo taken at our shop shows one of the City of Washington units being shipped, the other being fabricated—and the City of Detroit condenser being assembled.

These are small units, compared to many CONSECO has supplied, such as three of 70,000 sq. ft. each for the City of Los Angeles, Cal. . . . one 45,000 plus two 20,000 sq. ft. units for Puerto Rico . . . four 12,000 sq. ft. units and one 35,000 sq. ft. unit for Dairyland Power Cooperative . . . to mention just a few of scores of installations.

Big or small, CONSECO Equipment is the choice of Engineers who have well-placed confidence in CONSECO'S experienced engineering, sound design, dependable manufacturing and better performance. *Descriptive literature on CONSECO CONDENSERS on request.*

Send for Bulletins giving complete engineering data on these products.

EQUIPMENT DESIGNED AND BUILT BY CONSECO

HEAT EXCHANGERS • CONDENSERS • EVAPORATORS • STEAM JET AIR EJECTORS • CONDENSATE COOLERS • PRESSURE VESSELS SERVICE WATER COOLERS • FILTERS • STRAINERS • INSTRUMENTS, SPECIALTIES

15

CONDENSER SERVICE & ENGINEERING CO., INC. CONSECO

Designers and Builders of Equipment for Power, Refining, Chemical and Marine Industries

164 OBSERVER HIGHWAY
HOBOKEN, N. J.

More APPOINTMENTS

Begins on page 246

ter Company, Inc: Sam Gurley Jr. **Worthington Corporation:** Mason-Neilan division: Carl W Gram Jr. **Ford Instrument Co,** division of Sperry Rand Corp: A L Coulson.

New sales offices

Weston Electrical Instrument Corp: at 2001 S Grand Ave, Los Angeles, Calif.; at 7613 Reading Rd, Cincinnati, Ohio; at 101 N 33rd St, Philadelphia, Pa.; at Caldwell Ave and Route 22, Union, N. J. **H K Porter Company, Inc,** Delta-Star Electric division: at 542 S Broadway, Room 402, Los Angeles 13, Calif., G A Palka, manager; at 2308 4th Ave N, Room 205, Birmingham 3, Ala., L S Belding, manager; at 330 Grant St, Room 525, Pittsburgh, Pa., J F Zboyovsky, manager.

New sales engineers

Wright Engineering Company: Lee C Pulsipher, Pasadena, San Diego, southern California and Arizona areas. **Rawson & Co:** Robert E Moore. **Manning, Maxwell & Moore, Inc,** Industrial Controls division: Walter A White, Chicago district. **General Controls Co:** Morris P Stillinger, Los Angeles.

New representatives

For **Feedrail Corporation:** Cooper Page Company, 617 National Building, Minneapolis 2, Minn. For **Sorensen & Company:** Bivins & Caldwell, Inc, 3133 Maple Drive NE, Atlanta, Ga. For **Bryant Industrial Products Corp:** John M Shank Co, 5 Birchwood Ave, White Bear Lake, Minn. For **Warner Electric Brake & Clutch Company:** Richard Greene, 7 Armat Court, St. Louis, Mo.

Recent purchases, mergers

Chain Belt Co: acquisition of General Road Machines, Inc. **Sparks Withington Company:** purchase of all stock of Houston Pipe & Steel Company and combining of The Flori Pipe Company and Houston Pipe & Steel Company to constitute the pipe fabricating operation of the Sparks Withington Company.

Walworth Co: acquisition of all capital stock of Grove Valve and Regulator Company and Grove Controls, Inc. **H K Porter Company, Inc,** Laclede-Christy division: acquisition of refractory plant and property of the Robinson Clay Products Company.

New distributors

For **Hills-McCanna Co:** Sager-Spuck **Co:** Morris P Stilinger, Los Angeles.

(*Continued on page 252*)

Boiler feed water from this?

The grotesque creatures hanging here are simply salt-encrusted canvas-bagged anodes used in metal plating. The solution in which they are partially immersed contains a high percentage of metal salts such as those of copper, nickel, or chromium.

After the metals are plated in this bath, they are thoroughly rinsed, then polished or otherwise treated. Until recently, the rinse water—as much as 20,000 gallons a day in some plants—was discarded, valuable metals and all.

Today, treatment of the rinse water with AMBERLITE® Monobed ion exchange resins permits economical recovery of the metals *and of the water*. This water is of the same high quality as deionized water from standard water supplies—and can be used even for high pressure boilers.

Just think of what deionization with AMBERLITE Monobed resins can do for your water supply. Or, if you prefer the facts before you think about it, ask us for your free copy of "If You Use Water," 24 pages of detailed information.

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION, PHILADELPHIA 5, PENNSYLVANIA

How perfectly simple —this Fast's Coupling with purely mechanical flexibility!

1. A hub is keyed on each shaft. Hubs are splined at maximum distance from shaft ends.

2. Floating sleeves surround hubs. Sleeves are splined to engage hub splines.

3. Sleeves compensate for shaft misalignment by assuming neutral position between two hubs.

4. Because of distance from shaft end, any misalignment between splines is mere fraction of same misalignment between shafts.

5. Sleeves carried on bearing rings, located on *transverse center line* of hub spline faces (the load-carrying surfaces) — no crank action, no vibration.

6. Lubricant is centrifugally forced into spaces between engaged splines, forming a film.

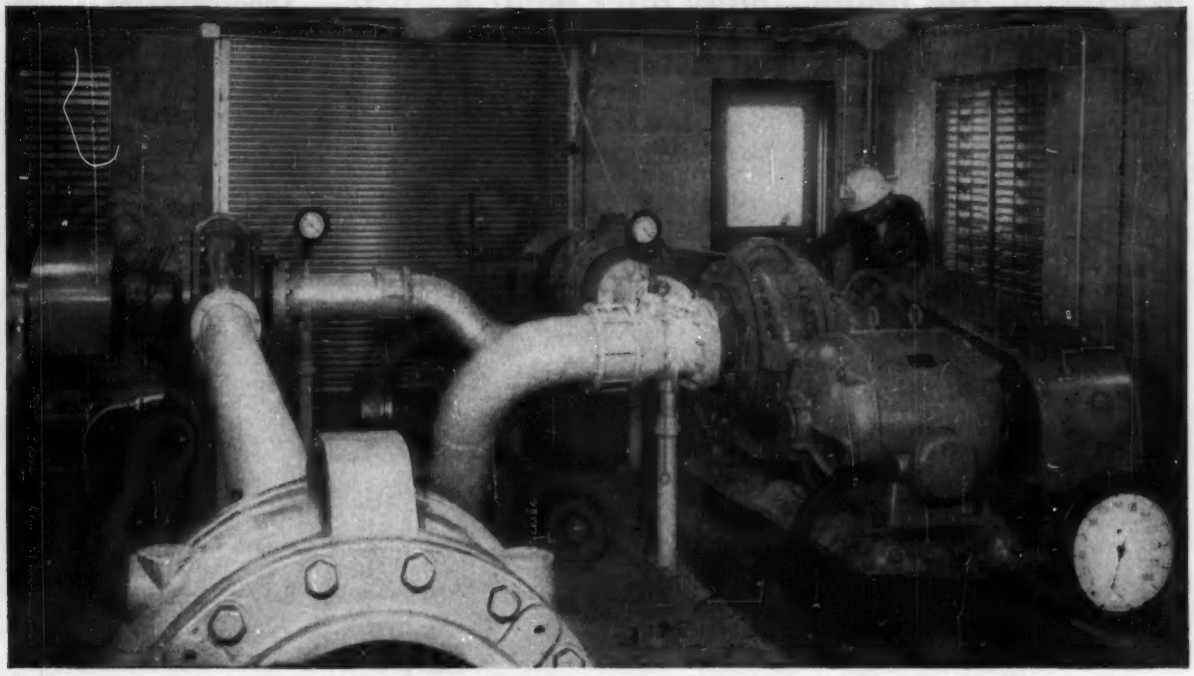
For 35 years the most positive, dependable means of coupling machines to their power source . . . Fast's Couplings have no parts subject to repeated bending, tension or compression. Because there is no metal-to-metal contact, *there is no wear*—in fact, many Fast's Couplings in use for over 30 years show no signs of wear when disassembled! No leather, plastic or rubber oil seals. Lubricant film distributes pressure over a considerable area, diminishing localized stress at pressure points on the load-carrying teeth. Perfectly simple? Yes . . . and foolproof!

For coupling catalog, technical advice or assistance from Koppers field engineers, write: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 3312 Scott Street, Baltimore 3, Maryland.

THE ORIGINAL **FAST'S Couplings**

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD.
This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans.
***Engineered* Products Sold with *Service*.**



High-speed abrasion — These Ni-Hard pumps move 16 tons of fly ash per hour against a head of 395 feet. Ni-Hard shells and impellers resisted heavy abrasion during 7100 hours of service without breakdown or replacement. "Hazleton" Ni-Hard pumps were built for Sunbury Plant of Pennsylvania Power & Light by Barrett, Haentjens & Co., Hazleton, Pa.

Fly ash pumps operate 7100 consecutive hours at Pennsylvania Power & Light's Sunbury plant

These are Ni-Hard* "Hazleton" pumps.

Five in all they dispose of fly ash slurry . . . pump it against a head of 395 feet at the Sunbury plant of Pennsylvania Power & Light Company.

In this gruelling test of service, they have given *7100 hours of service . . . moved 117,500 tons of fly ash without replacement of shells or impellers in any one of the pumps!*

What's more . . . they're *still* going strong!

This is the kind of service Ni-Hard castings turn in time after time under severe abrasion conditions.

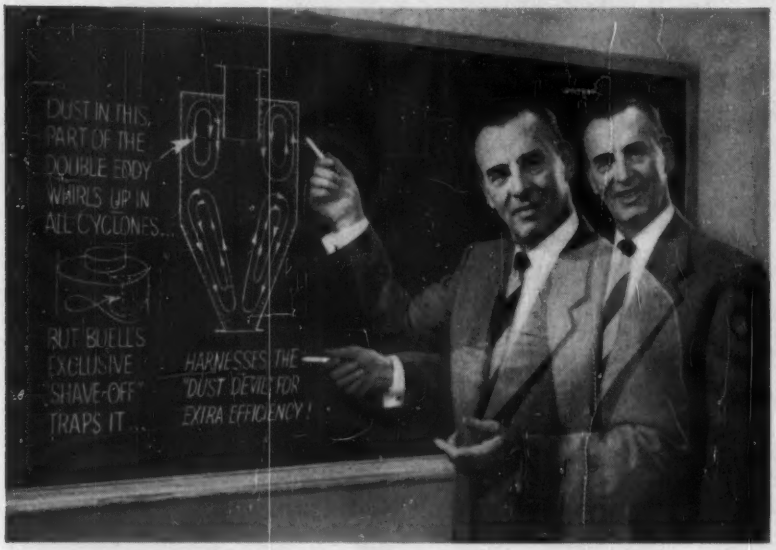
That's because Ni-Hard iron is hard and wear resistant — properties necessary for tackling tough jobs like this one at Sunbury. In fact, this nickel-chromium white iron is often the one practical answer for pump parts and critical pipe line sections.

If you need high abrasion resistance in your equipment specify Ni-Hard castings. They will improve service . . . lower maintenance and repair costs. We'll be happy to offer suggestions on solving your abrasion problem. Write INCO for information.

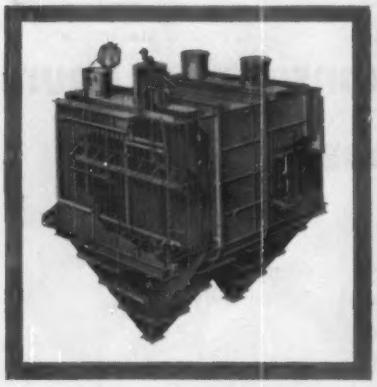
*Registered trademark

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N.Y.

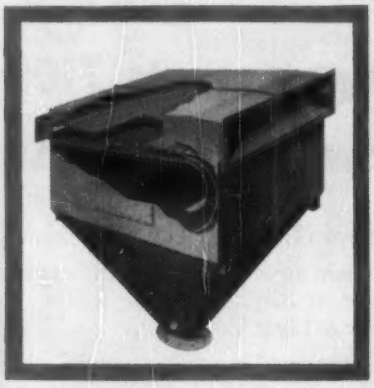
Mastering the double-eddy dust devil leads to extra dust collection efficiency!


DUST IN THIS PART OF THE DOUBLE EDDY WHIRLS UP IN ALL CYCLONES...
BUT BUELL'S EXCLUSIVE "SHAVE-OFF" TRAPS IT...
HARNESSES THE "DUST DEVIL" FOR EXTRA EFFICIENCY!

Other design features which increase efficiency include large, clog-proof diameter, proper proportioning for maximum dust separation, extra-heavy-gauge, wear-resistant construction . . . features which shave dust collection costs to the minimum!



Buell SF Electric Precipitator also delivers *extra dust collection efficiency*, due to unique Spiralectrodes and Continuous Cycle Rapping.



Buell Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for either natural or mechanical draft installations.

For more specific data about Buell's *extra efficiency*, write Dept. 50-L, Buell Engineering Company, 70 Pine St., New York 5, N. Y.

buell®

MECHANICAL ELECTRICAL

Experts at delivering Extra Efficiency in

DUST COLLECTION SYSTEMS

More APPOINTMENTS

Begins on page 246

Coles Cranes, Inc: W S Murphy Co, 598 Ponce de Leon Ave, NE, Atlanta, Ga. For **United States Gauge div of American Machine and Metals Inc:** M S Jacobs & Associates Inc, 810 Noblestown Rd, Pittsburgh 5, Pa.

Atomic Industrial Forum, Inc: Alfred Iddles, president; Gordon Dean, Francis K McCune, Earle W Mills, vice-presidents. **Engineers Council for Professional Development:** Morris D Hooven, president. **Stanford Research Institute:** E Finley Carter, director.

Institute elections

Instrument Society of America: Justus T Vollbrecht, president. **American Society of Civil Engineers:** Mason G Lockwood, president. **National Association of Power Engineers:** J Dudley Holmes, vice-president. **Stanford Research Institute:** E Finley Carter, director. **Southwest Research Institute:** Edward Wenk Jr, chairman of dept of engineering mechanics.

Obituaries

A T Wendler, Pittsburgh branch manager of The Fairbanks Company, on September 15th.

Peter T Reuter, 58, manager of the Boston district office of Bailey Meter Company, on October 5th.

David S Faulkner, 70, retired vice-president of The National Supply Company, on October 11th.

Frederic A Loeffler, 55, director of labor relations for Alco Products, Inc, on October 21st.

An 11-minute sound-slide film about a pipe insulation that is said to save up to 50 percent in installation time has been released by the Insulation Div of the Armstrong Cork Co. Interested groups may contact any Armstrong district office, or the Co's Insulation Div, Lancaster, Pa., to arrange for a showing.

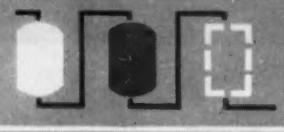
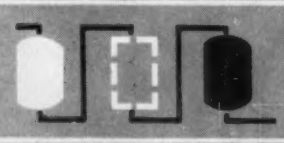
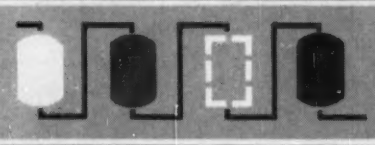
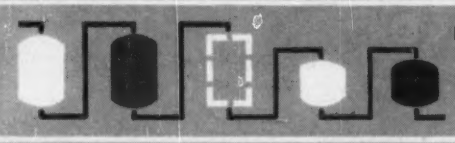
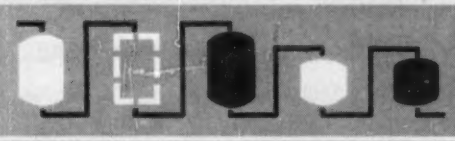
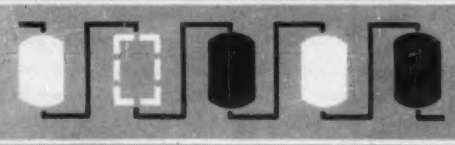
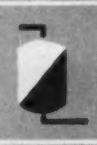
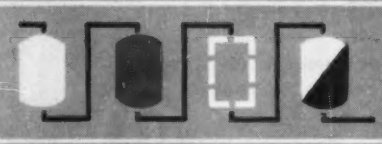
"Better hide these packing pullers until after the first of the year."

9 ways to demineralize water

(BY ION EXCHANGE)

KEY:

- Hydrogen Cation Unit — Removes metallic cations such as calcium, magnesium, sodium. Regenerated with sodium for simple water softening.
- Weakly Basic Anion Unit — Removes strongly ionized acids such as sulfuric, hydrochloric, nitric.
- Strongly Basic Anion Unit — Removes strongly ionized acids, also weakly ionized acids such as silicic and carbonic.
- Mixed Bed Unit — Contains both Hydrogen Cation and Strongly Basic Anion Exchangers, intimately mixed.
- Degasifier — Optional. Reduces load on Strongly Basic Anion Exchanger by removing free CO_2 brought in by raw water or developed in cation unit.

A		Effluent Conductivity—10 to 20 micromhos (no silica reduction)	Uses low-cost anion exchanger and anion regenerant (soda ash). Typical use—removing soluble salts from water for ceramic mixes and slips or from rinse waters used before painting, mirror silvering, etc.
B		Effluent Conductivity—same as A. Silica content—0.02 to 0.15 ppm.	Used for treating feedwater for boilers in general range of 600 to 1400 psi. Also (without degasifier) for removing impurities from plating baths and recovering chromate from plating rinses.
C		Same effluent as B.	For raw water with high sulfate and chloride content. Low-cost Weakly Basic Anion Exchanger removes major portion of electrolyte load. Countercurrent regeneration of anion units reduces operating costs.
D		Effluent Conductivity—3 to 5 micromhos. Silica same as B.	For same type of raw water as C. Countercurrent regeneration of both cation and anion units cuts operation costs.
E		Effluent Conductivity—1 to 3 micromhos. Silica same as B.	For waters where alkalinity is a major part of the anion content. Polishing units require infrequent regeneration. Produces, at low cost, low-solids feedwater suitable for high pressure boilers (over 1400 psi).
F		Same effluent as E.	High flexibility of operation. Can operate in parallel for peak flows. Can maintain service flow during regeneration of either pair of units.
G		Effluent Conductivity—less than 1 micromho. Silica same as B.	Produces effluent of extremely high quality. Suitable for "super critical" pressure boilers and atomic reactors. (Initial and operating costs are usually higher than for separate anion and cation units.)
H		Same effluent as G.	For raw water with high sulfate and chloride content. Two-step demineralizer reduces load on Mixed Bed unit, cuts operating cost. (Strongly Basic Anion Exchanger is used in place of Weakly Basic where raw water has high silica and alkalinity.)
I		Same effluent as G.	Recommended where alkalinity of raw water is high. Cation unit and Degasifier reduce load on Mixed Bed unit, cut operating costs.

All of the above systems, with equipment and resins made by Permutit, are in commercial use. Other combinations are possible—also use of special ion exchangers such as PERMUTIT SK for separating uranium oxide from other metallic oxides in ore.

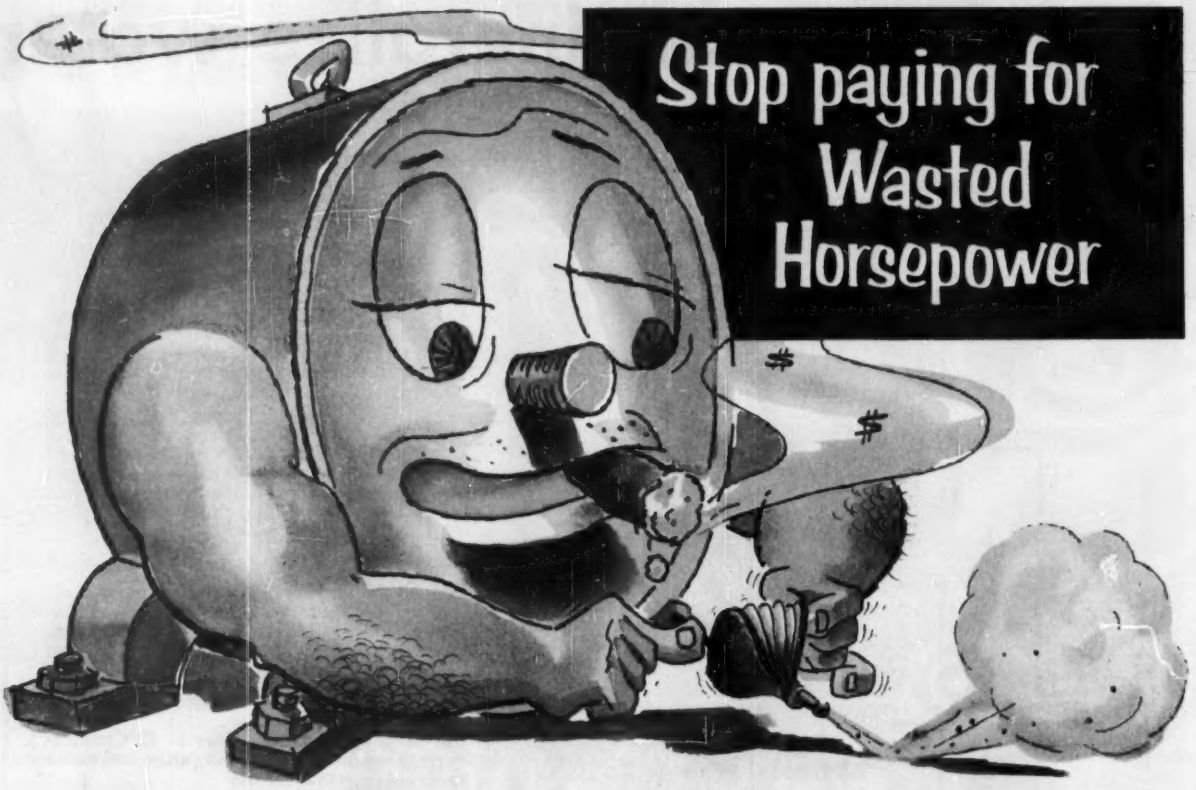
Most of these systems (C and higher) are used almost exclusively for demineralizing feedwater for high-pressure boilers . . . but the list of possible applications in other fields is growing.

If you have a problem ion exchange might solve, we'll be glad to study it with you and bring you the benefits of this experience. Address: The Permutit Company, Dept. P-12, 330 West 42nd St., New York 36, N. Y.

PERMUTIT®

rhymes with "compute it"

ION EXCHANGE for Water Conditioning
Chemical Processing • Industrial Waste Treatment



Stop paying for Wasted Horsepower

Just match your average load . . . let silicones carry the overloads

If you specify horsepower to equal "peak overloads," your motors work at full rated capacity only part of the time — you're paying for unused horsepower. Today, silicone insulation has outmoded this kind of wasteful over-motoring. Motors insulated with Dow Corning Silicones have a service factor of 25 to 50% . . . so now you can merely match your average load, and let this *built-in* service factor handle intermittent overloads.

Lower your motor costs! For every dollar wasted on unused motor capacity, you spend an additional $3 for starters, cable, transformer capacity and installation. Silicone insulated motors *save* you real money!

Boost your production! Motors insulated with Dow Corning Silicones have much greater resistance to heat, moisture, and corrosive atmospheres . . . assure *more continuous production.*

Remember, over-motoring is outmoded

Get sources for silicone insulated equipment—mail coupon today

Dow Corning Corporation, Dept. 6912, Midland, Mich.

Please send me sources for Silicone insulated
☐ Motor ☐ Transformers ☐ and Reprint
"New Developments in Silicone Insulation."

NAME _____ TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

Here's more proof for you...

The Philip Sporn plant on the American Gas and Electric System installed its first silicone insulated motor over 6 years ago . . . a 1000 hp, 1190 rpm forced draft fan motor built by the Elliott Co. Smaller and less costly to install than an equivalent 1500 hp conventional motor, this unit has been operating in ambient temperatures up to 120 F without a sign of failure to date. Starting against cold air 4 times a day, it is overloaded by 30% bringing its total rise to 250 F with an output of 1300 hp. This kind of dependable performance has led American Gas and many other leading utilities to standardize on silicone insulated auxiliary motors.

DOW CORNING SILICONES

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

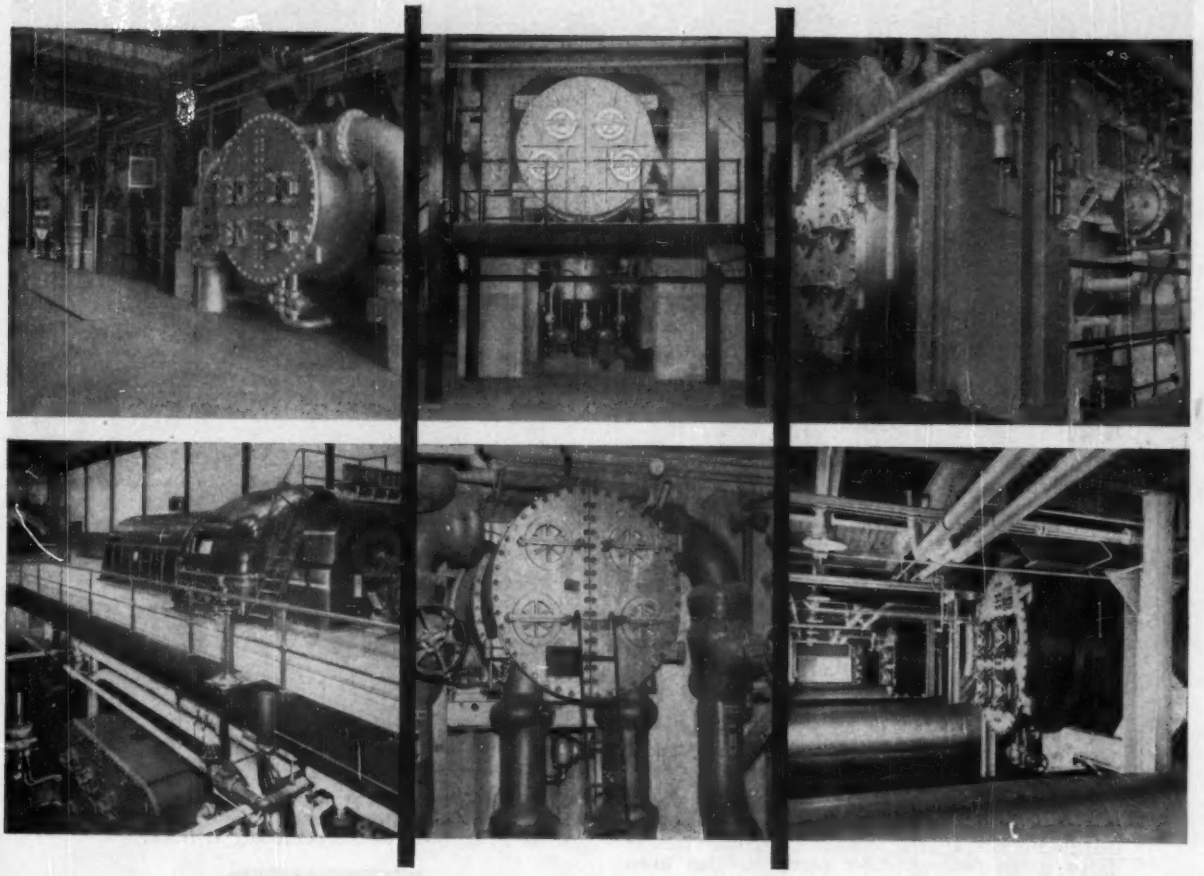
ATLANTA • CHICAGO • CLEVELAND • DALLAS • DETROIT
LOS ANGELES • NEW YORK • WASHINGTON, D. C. (Silver Spring, Md.)

CANADA: Dow Corning Silicones Ltd., Toronto
GREAT BRITAIN: Midland Silicones Ltd., London
FRANCE: St. Gobain, Paris

the fame of a good product travels far . . .

ROSS SURFACE CONDENSERS

serve power plants everywhere



Pre-eminence of Ross engineering and manufacturing has won many customers . . . and kept them . . . here and abroad.

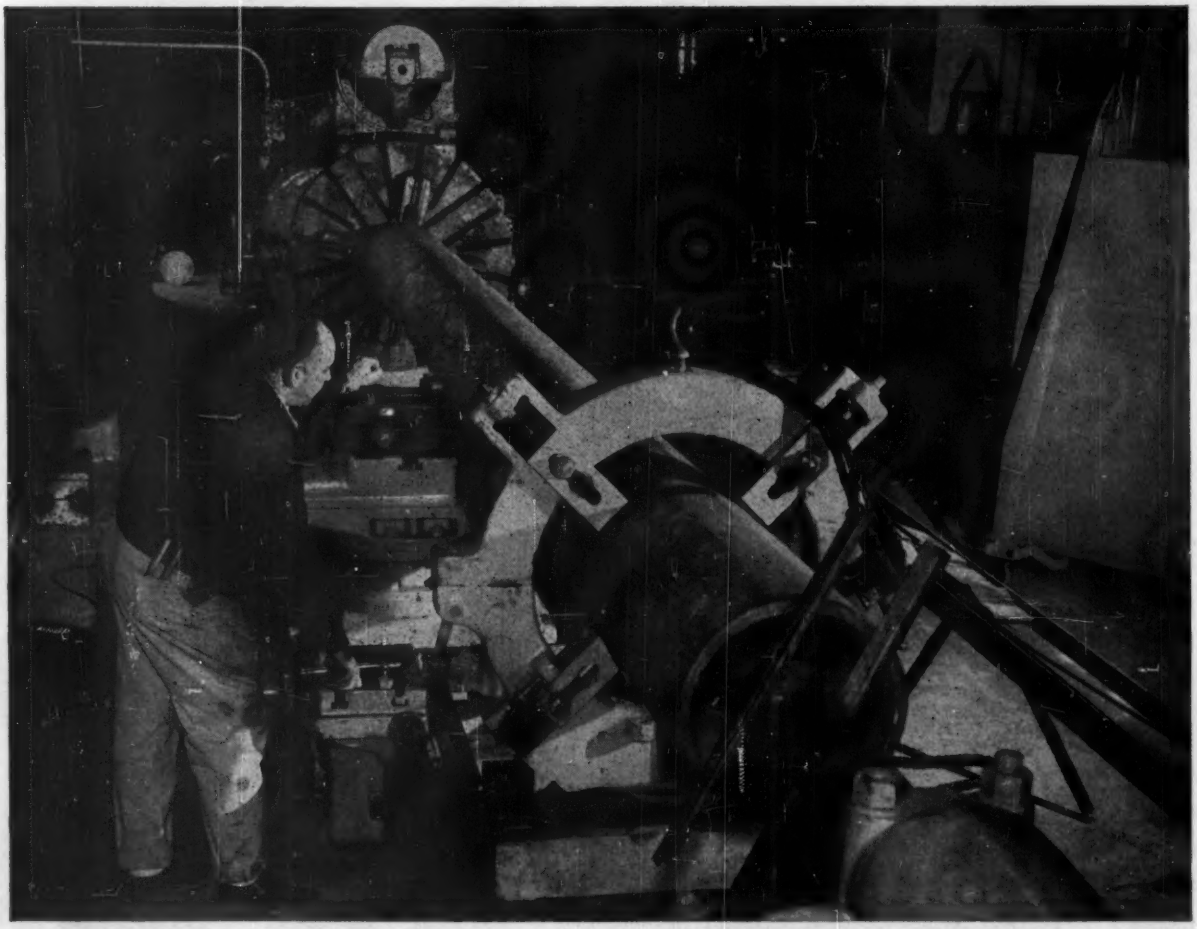
Public utilities, municipalities, industries, institutions, office buildings . . . some equipped with large twin bank designs, others with smaller single bank units . . . number among Ross installations which date back 40 years.

Long a leading, exclusive producer of heat exchange and condensing equipment . . . long a pace-setter with major innovations . . . Ross has a versatile experience to offer in the interpretation *and fulfillment* of your requirements. Consulting engineers, contractors, architects or plant men . . . whoever specifies . . . all like to work with Ross engineers in the solution of condensing and heat exchange problems.

New Bulletin 8.2K1 gives you the reasons why. Write for your copy, please. Ross Heat Exchanger Division of American-Standard, Buffalo 5, N. Y. In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

ROSS

ROSS HEAT EXCHANGER PRODUCTS



ALCO FACILITIES ASSURE VALUE IN PREFABRICATED PIPE

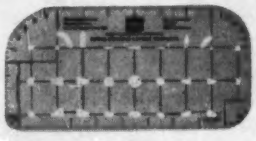
Machines and Methods at ALCO's Plant Handle All Sizes of Seamless Pipe, Any Alloy or Grade; Modern Welding Techniques Used for All Materials.

ALCO brings to prefabricated pipe production a modern plant, completely equipped with machine tools to handle any size, alloy or technique. Facilities include large lathes *(above)*, other heavy machine tools, induction heat-treating for joint preheat and stress relief after welding.

Advanced quality control methods are another important factor in ALCO prefabricated pipe. Use of X-ray machines and cobalt 60 pills to test welds is an example of up-to-date inspection and test procedures.

Experience and production know-how are also factors in ALCO prefabricated pipe. Pipe manufacture draws on welding techniques which have placed ALCO in a leading position in the welding field. ALCO's experience in heat-exchange equipment, both refinery and power plant, aids in piping manufacture.

Your inquiries on ALCO piping will receive prompt handling at any ALCO Sales Office, or, if you wish, write P. O. Box 1065, Schenectady 1, N. Y.



Information on how to obtain the ALCO piping drawing layout template, a definite aid in making piping layouts, is available from ALCO, P. O. Box 1065, Schenectady 1, N. Y.

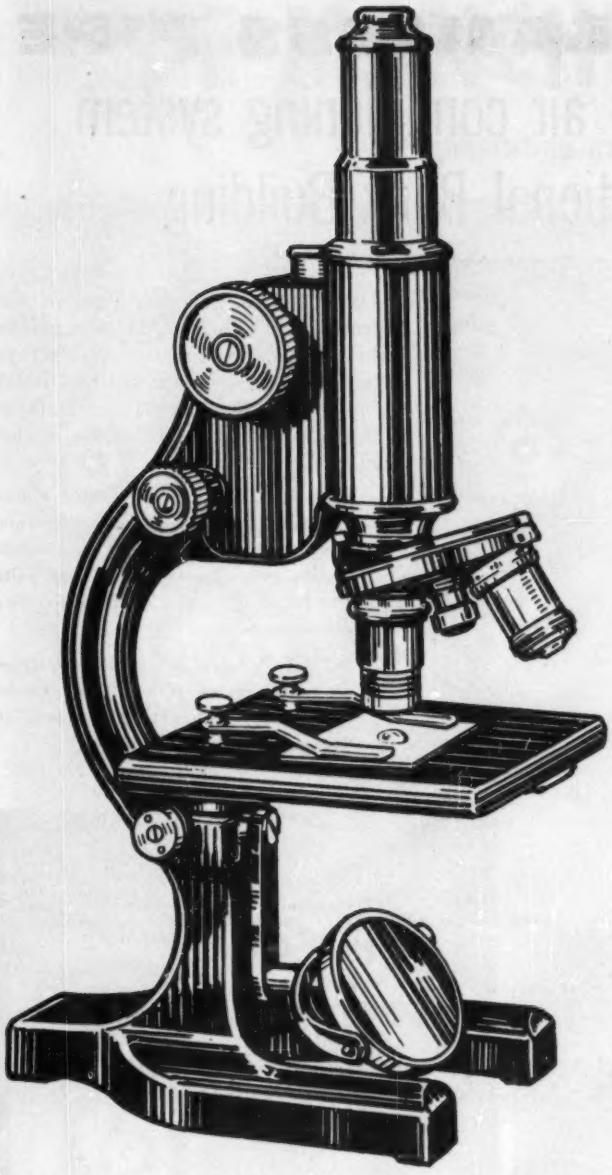
ALCO

ALCO PRODUCTS, INC.

NEW YORK

Sales Offices in Principal Cities

Locomotives · Diesel Engines · Nuclear Reactors · Heat Exchangers · Springs · Steel Pipe · Forgings · Weldments · Oil-Field Equipment



In Water
it's often what you can't see that hurts you!

Anyone concerned with water-using equipment is perfectly aware that you can't see the dissolved minerals in ordinary water... the kind of water that can cause trouble and expense wherever it is used. This is just our way of reminding you that thousands of plants, institutions and other water users throughout the country are avoiding trouble and expense with Elgin Water Conditioning equipment.

Based upon scientific water analysis and a thorough study of your problem, Elgin will submit a complete proposal covering the type of water treating system which will give you the best and most economical service. This may mean simply ion-exchange softened water. Or, maybe analysis indicates need for dealklization, neutralization or silica and CO_2 removal. At the other extreme, your operations may require water free of all minerals, alkalinity, acidity, gases ... in short *chemically pure water* by means of deionizer equipment.

Whatever the case may be, Elgin equipment and Elgin water treating methods, plus Elgin experience and skill, can solve your problems... with maximum efficiency at minimum cost. Talk over your water problems with the Elgin representative in your vicinity who can put at your disposal all the skill and knowledge of Elgin's half-century of service. Or write us direct.

ELGIN WATER CONDITIONING SINCE 1908

ELGIN SOFTENER CORPORATION

130 No. Grove Avenue, Elgin, Illinois

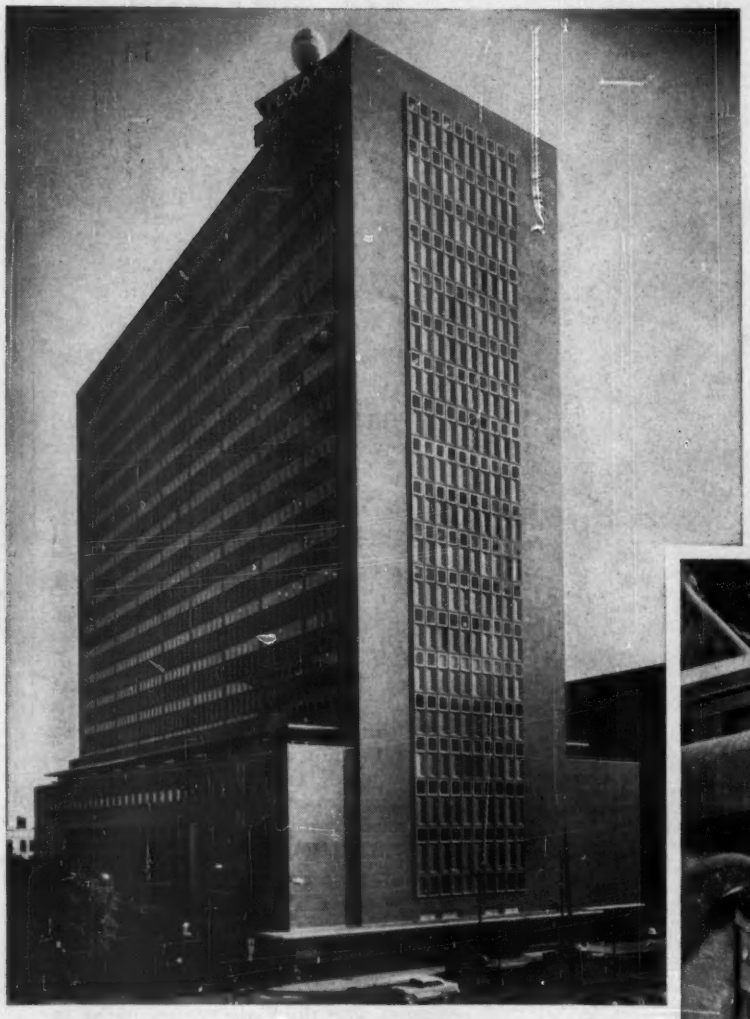
Representatives in Principal Cities

In Canada: G. F. Sterne & Sons Ltd., Brantford

SOFTENERS ION EXCHANGERS FILTERS DEIONIZERS DEALKALIZERS LIME COAGULATORS DEGASITORS DEAERATING HEATERS

NATIONAL SEAMLESS PIPE

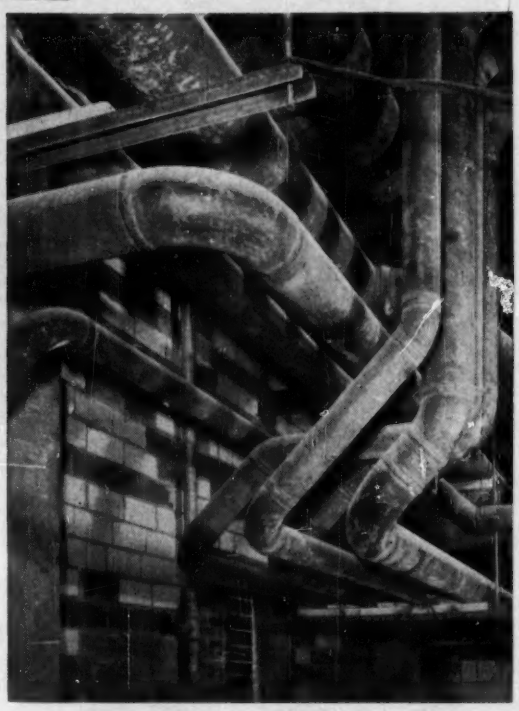
used for heating and air conditioning system of new Texas National Bank Building



USS National Seamless Pipe, in sizes from 4" O.D. to 16" O.D., was utilized in the heating and air conditioning system of this new Houston, Texas, building, owned jointly by Texas National Bank and Continental Oil Co., as follows:

Sizes 4", 6", 8", 10" and 12" are used for combination hot and chill water lines to the primary and zone conditioners as well as the perimeter units. The 16" O.D. pipe is used for handling condenser water.

The 14" O.D. pipe is part of the steam piping system which in turn converts the water into hot water for heating through the use of converters.



USS National Seamless Pipe is consistently the number one choice of engineers and contractors throughout the country for air conditioning, heating and power installations. Its ability to render efficient, trouble-free service under all types of pressure and temperature conditions has given National Seamless a reputation for safety and dependability excelled by no other pipe. For further information, or assistance with your pipe problems, get in touch with our engineers.

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

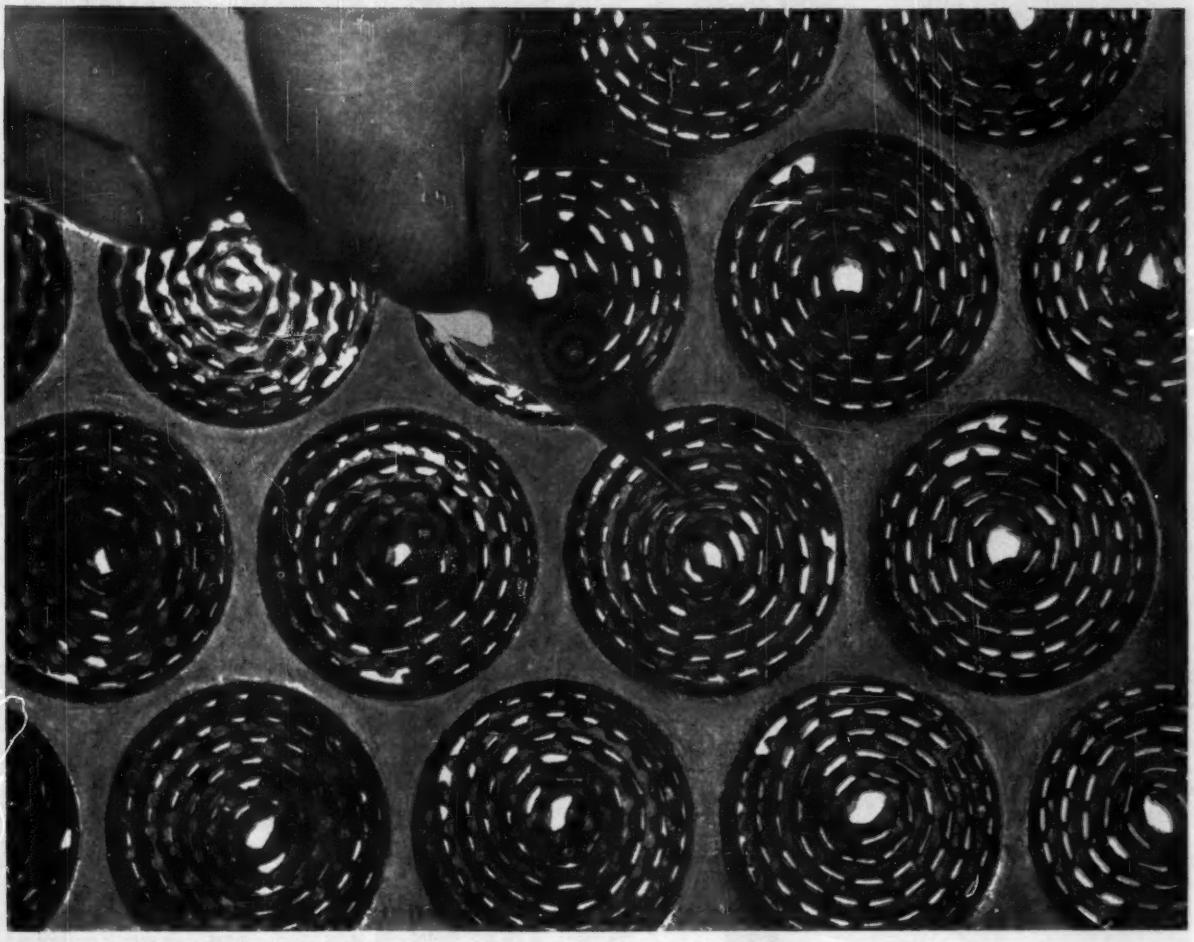
NATIONAL Seamless PIPE AND TUBES

WALLS WITHOUT WELDS

UNITED STATES STEEL

EXIDE-MANCHEX BATTERIES

For generating and substations



Open "windows" for electrolyte insure immediate power

SWITCHGEAR BATTERY. Models available in capacities from 8 to 960 ampere-hours. Write for Bulletin No. 4852.

The reason Exide-Manchex Batteries outperform other Plante-type batteries is the way they're made. For example, of all batteries on the market today, only the Exide-Manchex gives free access of electrolyte all the way into the center of the positive plate.

You can see this in the picture of the Exide-Manchex positive plate shown above. Heavily corrugated lead strips are rolled into spiral buttons and forced into the positive plate grid. Held up to the light, an Exide-Manchex positive plate shows thousands of tiny openings over its entire surface—openings that pass completely through the plate. Wherever light is, electrolyte goes. Each opening is a tunnel that gives the electrolyte free access to the entire effective surface area of the Exide-Manchex positive plate—hence the power is there when called for.

This unique construction is only one of the many reasons Exide-Manchex Batteries prove so superior in so many applications. When you order batteries for floating service applications, or the equipment that requires such batteries, be sure to specify Exide-Manchex. Write for detailed bulletin. Exide Industrial Division, The Electric Storage Battery Company, Philadelphia 2, Pa.

Exide®

Best way to solve your tube corrosion problems

What condenser tube alloy best meets *your* specific operating conditions? What effect will a change of alloy composition have on *your* operating and maintenance costs? Will future changes in operating schedules impair the efficient functioning of *your* tubes?

Best way to answer these and many other questions affecting your condenser tube selection is to ask Bridgeport. Our 60 years of tube manufacturing and corrosion research, backed by modern methods and facilities, have led to the development of a wide range of tube alloys to meet virtually every corrosion problem. Here are some of the standard tube alloys Bridgeport offers:

Admiralty – Good corrosion resistance to most types of circulating water at low velocities. Resists dezincification. Excellent corrosion resistance to clean fresh water and in certain types of industrial and sewage pollution. A common choice for power stations for condensers, feed water heaters and heat exchangers.

Aluminum Brass – Excellent corrosion resistance to sea water. Resists impingement corrosion in water velocities from 6 to 10 ft. per second. Excellent corrosion resistance to chlorinated sea water when chlorine is used for slime control. Excellent corrosion resistance to clean and polluted fresh water. Ideal for severe operating conditions. Widely used by seaboard power stations for condensers and heat exchangers.

Copper – Good general corrosion resistance. Good impingement corrosion resistance where water velocities are low. Immune to dezincification. Resistance to cracking high. Excellent heat transfer rate. Widely used for heat exchangers, evaporaters and condensers, particularly for fresh water services.

Cupro Nickel – Considered the best copper-base alloy for all-around and impingement corrosion resistance toward sea water and saline waters. Has unusually high strength at elevated temperatures.

Aluminum Bronze – Good general resistance to impingement and corrosion in brackish water and in areas where water is contaminated by sewage and acid wastes.

Red Brass – Good corrosion resistance in fresh water. Excellent resistance to dezincification.

Muntz Metal – Similar to Admiralty in resisting corrosion effects of sea water. Resists dezincification in sea water and brackish water. Excellent resistance to corrosion in most fresh waters.

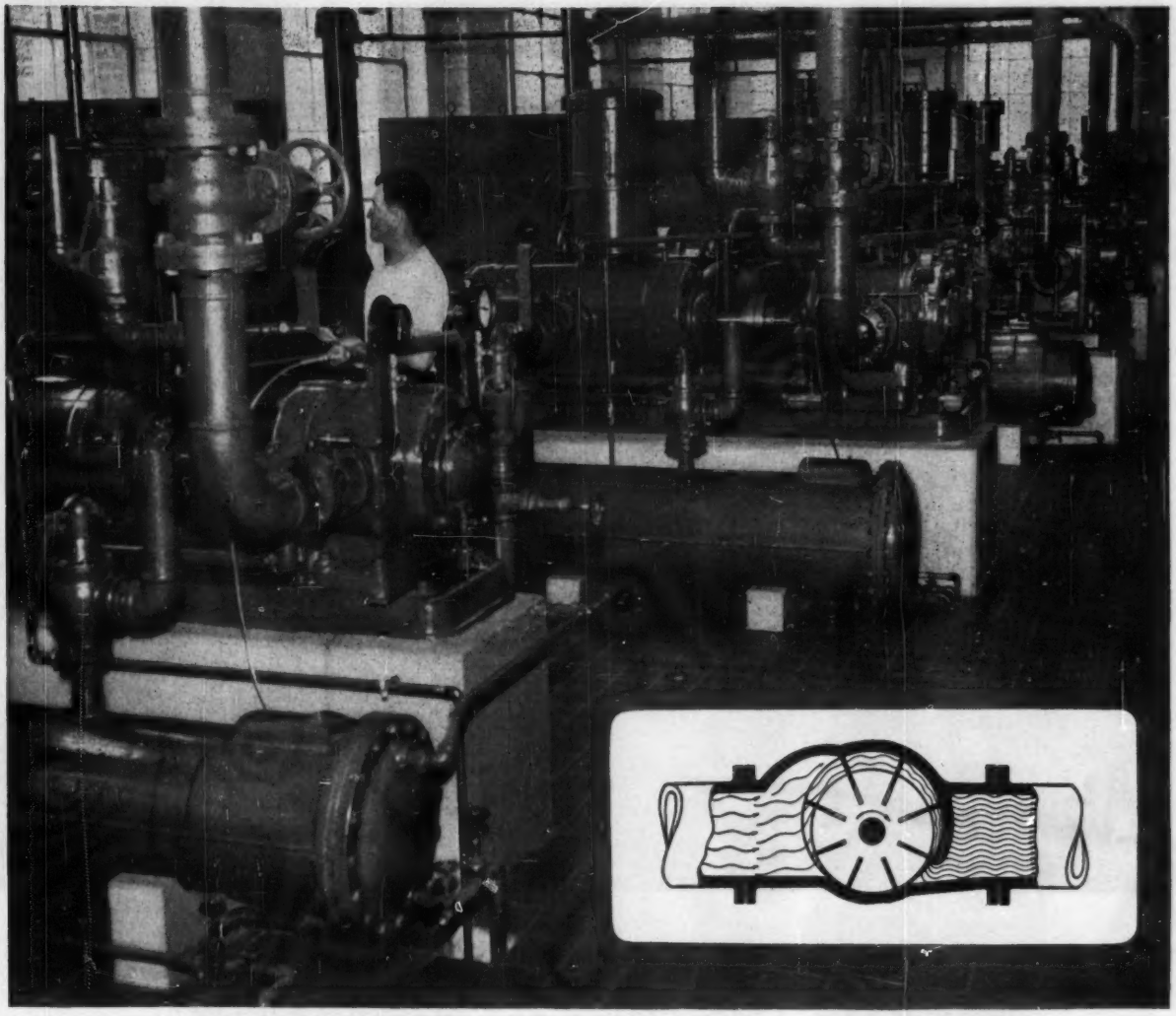
Bridgeport's Technical Service and Corrosion Laboratories are at your service to help you with specific problems. Call your nearest Bridgeport Sales Office for complete information.

The Bridgeport Condenser Tube Handbook *has 162 pages of valuable information on corrosion and how to combat it. Write for a copy.*

BRASS Bridgeport CO.

BRIDGEPORT CONDENSER TUBES

Bridgeport Brass Company, Bridgeport 2, Conn. • Offices in Principal Cities
In Canada: Noranda Copper and Brass Limited, Montreal



Industrial Pressures Up To 125 psig
Capacities to 3300 cfm

When you need such performance, it will pay you to specify Fuller vane-type Rotary Compressors. They provide the simplest, most economical and most reliable source of compressed air for all pneumatic plant services.

These compressors have a minimum number of moving parts, (rotor, blades and bearings) employ direct-connected motor drive, and operate with an incredible lack of vibration. They run for days without requiring operational attention, and are ideal for continuous service in out-of-the-way locations.

Detailed information on design characteristics, and typical applications will be forwarded promptly on request.

Fuller
. . . . pioneers in harnessing AIR

FULLER COMPANY, 126 Bridge St., Catasauqua, Pa.
GENERAL AMERICAN TRANSPORTATION CORPORATION SUBSIDIARY
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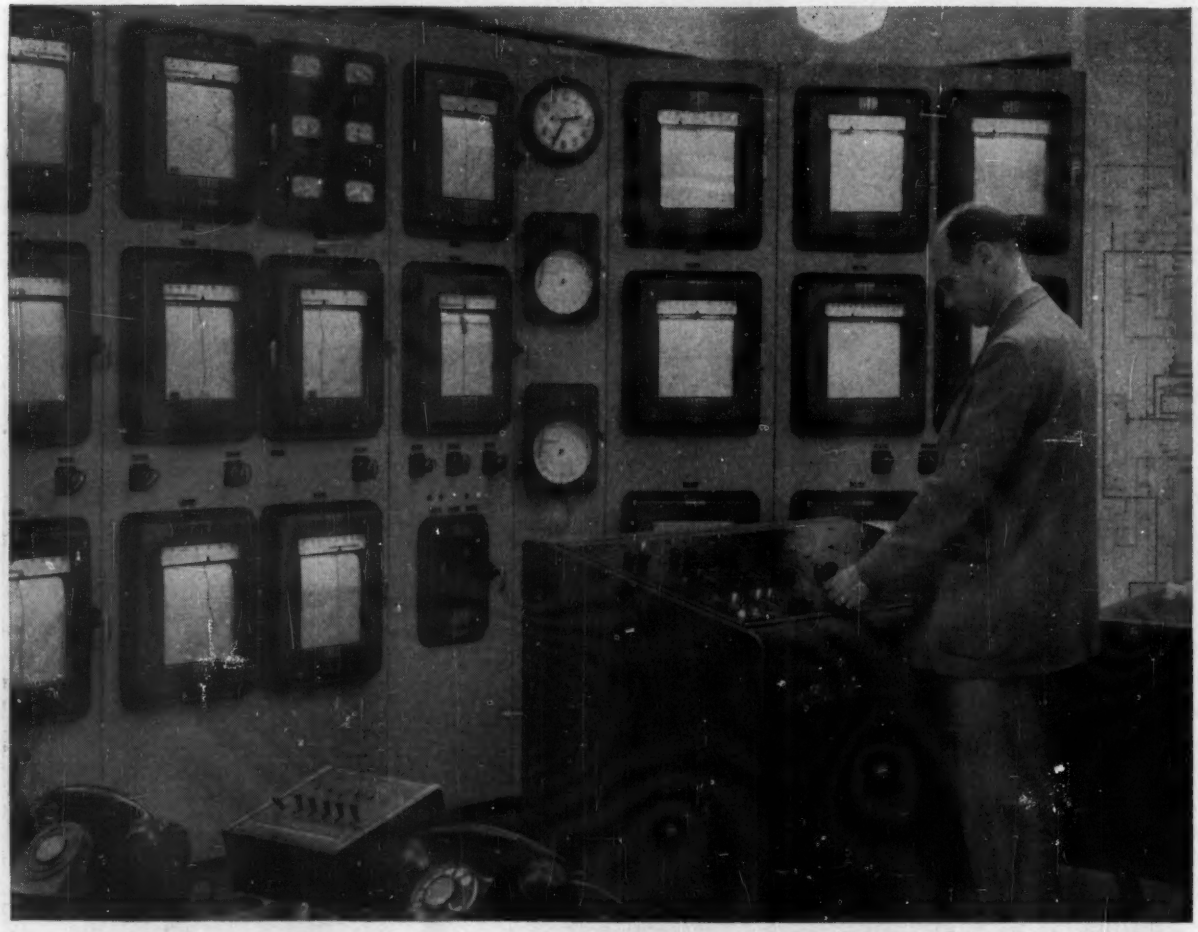


Photo courtesy Public Service Co. of Oklahoma

He's Using an "Idea Amplifier" to solve a cost-cutting problem

This Load Dispatcher's aim at the moment is to coordinate regulation of hydro and steam generation. On paper at least, this coordination contributes to lowest-cost operation, but in actual practice, its execution involves numerous factors —many of them variables, and far too complex to be calculated manually in a hurry.

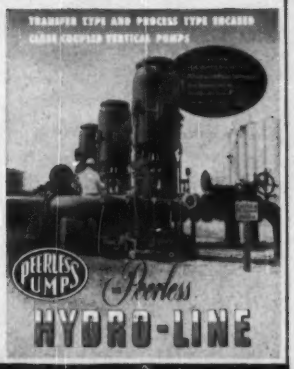
So the Dispatcher turns to electronics for amplification and execution of his idea. He uses the console in front of him to convert it to an electrical equivalent which is instantly calculated and telemetered in the form of control pulses to any given number of turbine governor motors simultaneously . . . and it's all done with cost-cutting accuracy beyond the ability of even the best manual operation.

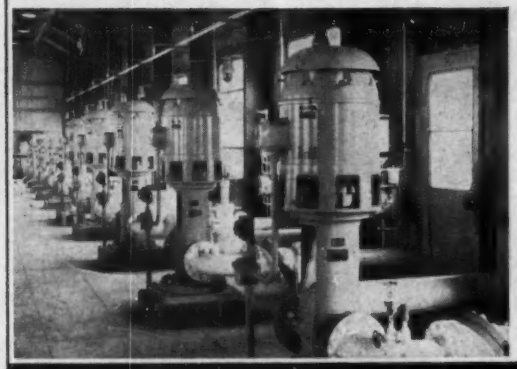
The "amplifier" in this case is an Area Load Control console—a device with computing circuits that functions as the brain of each Leeds & Northrup Area Load Control system. Already, these custom-engineered systems are installed on utility networks accounting for nearly a *third* of American generation.

Operating flexibility of Area Load Control is one reason for this preference. For when day-to-day operating conditions change (due to wet coal, loss of a cooling fan, unscheduled maintenance, etc.) Area Load Control provides the Load Dispatcher with the necessary flexibility to meet these problems as they arise.

Next time you have an opportunity, talk with your power neighbors who use Area Control—get the benefit of their thinking plus the ideas of your own operating staff. It's a method for turning in cost-cutting recommendations that work.

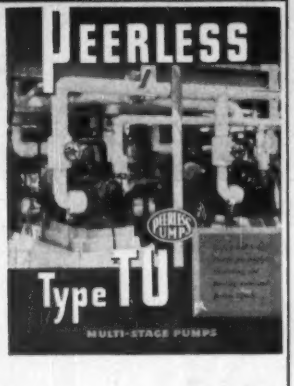
either way YOU LOOK AT THE PUMPING PROBLEM





VERTICAL

Horizontal



PERFORMANCE-PROVED PEERLESS PUMPS WILL DO THE JOB BETTER

Here's why—You can choose from either Peerless vertical or Peerless horizontal designs for most every liquid transfer job—water or process liquids. You can select the pump you need from the broadest range of heads, capacities and horsepowers.

You can buy and apply a Peerless pump with the confidence that it will provide dependability over the years.

Bulletin B-1700, at the top above, describes Peerless vertical can type process pumps. Bulletin B-1400 just above describes multi-stage horizontal pumps for high pressure liquid transfer.

Write for your copies. You'll find out how Peerless pumps can squarely meet your pumping needs with economy, efficiency and dependability.

PEERLESS PUMPS

fmc FOOD MACHINERY AND CHEMICAL CORPORATION

PEERLESS PUMP DIVISION

FOOD MACHINERY AND CHEMICAL CORPORATION

Factories: Los Angeles 31, Calif., and Indianapolis 8, Ind.

Offices: New York; Atlanta; Chicago; St. Louis; Indianapolis, Ind.; Phoenix; Fresno; Los Angeles; Plainview and Lubbock, Texas; Albuquerque, New Mexico.

Distributors in Principal Cities. Consult your Telephone Directory.

PEERLESS PUMP DIVISION
Food Machinery and Chemical Corporation
301 West Avenue 26, Los Angeles 31, California

Please send bulletins checked below:

☐ PEERLESS HYDRO-LINE CAN TYPE PUMPS (B-1700)

☐ PEERLESS MULTI-STAGE HORIZONTAL PUMPS (B-1400)

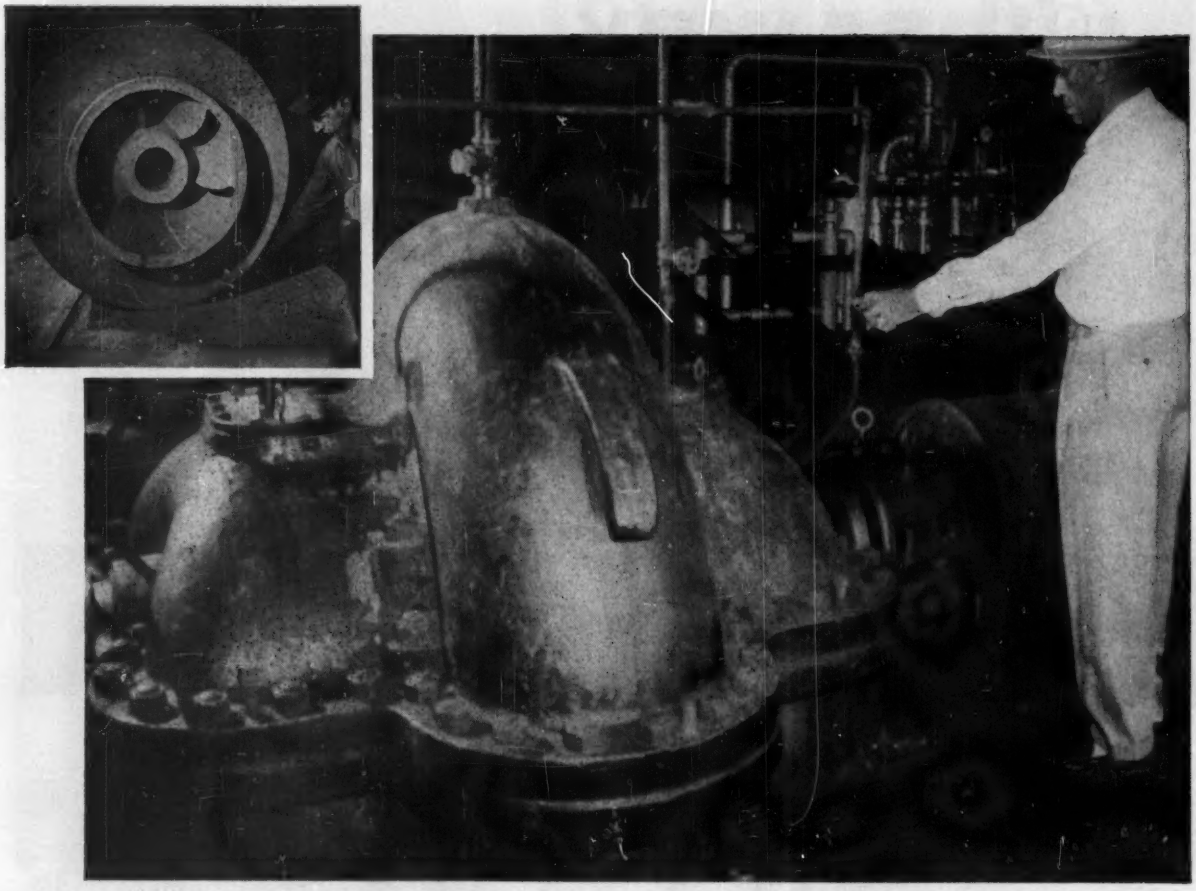
NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

POW



No Slow Joe. This power plant pump handles 240,000 gallons of salt water every hour. Its 2,200-pound impeller – cast by the INCO Foundry at Bayonne, N. J. – is shown at upper left. To meet Caloil demands for *utmost* corrosion resistance, it's made of *Monel!*

Pumping salt water at 40,000 gpm

Monel impeller helps coastal power plant end threat of breakdown by corrosion

The California Oil Company has a big industrial power plant at Perth Amboy, New Jersey. Right at hand is all the water they need for their cooling system.

But it's *salt* water. And you know how destructive that can be . . . what corrosion it can cause.

So Caloil had an impeller of Monel* nickel-copper alloy put in. Weighing 2,200 pounds, it was specially cast at INCO's Foundry in Bayonne, New Jersey.

This large Monel casting has excellent resistance to corrosion. And it's *tough*, too! Actually, Monel lends more strength than the impeller *needs* to stand centrifugal stresses and plenty of hardness to resist wear.

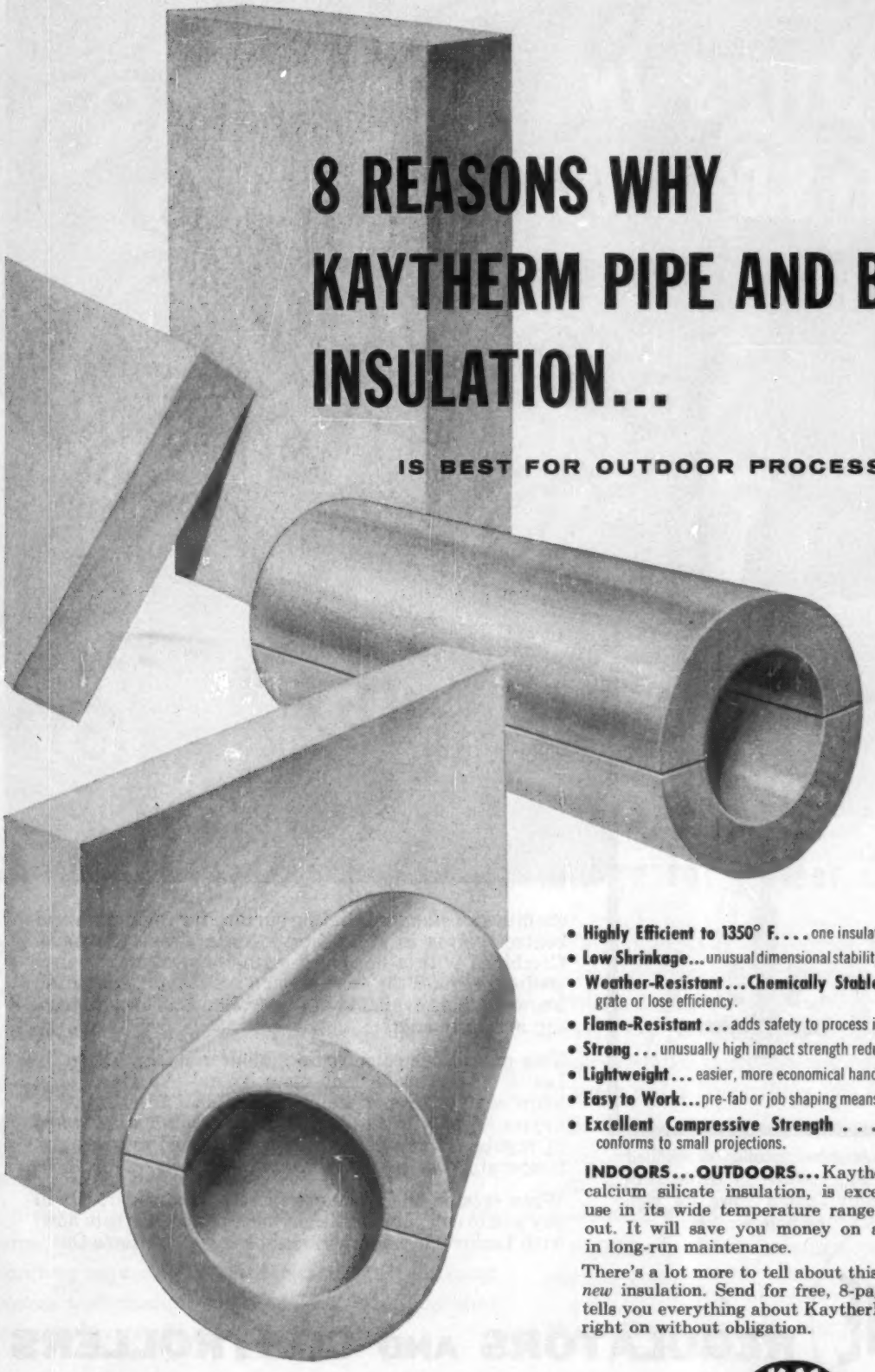
Over and over, that's the way it is with Monel. It gives you an *extra* margin of performance. Helps make your equipment last longer. Helps keep your maintenance expense low. And helps make downtime less of a threat!

There are probably *many* ways Monel can save money for you. Find out more about them. Ask for "Engineering Properties of Cast Monel" and "Cast 'S' Monel." Write today!

*Registered Trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

More POWER for you . . . with MONEL — **INCO NICKEL ALLOYS** (TRADE MARK)



8 REASONS WHY KAYTHERM PIPE AND BLOCK INSULATION...

IS BEST FOR OUTDOOR PROCESSING

- **Highly Efficient to 1350° F....** one insulation with many uses.
- **Low Shrinkage...** unusual dimensional stability reduces heat losses.
- **Weather-Resistant...Chemically Stable...** doesn't disintegrate or lose efficiency.
- **Flame-Resistant...** adds safety to process industries.
- **Strong...** unusually high impact strength reduces breakage losses.
- **Lightweight...** easier, more economical handling and application.
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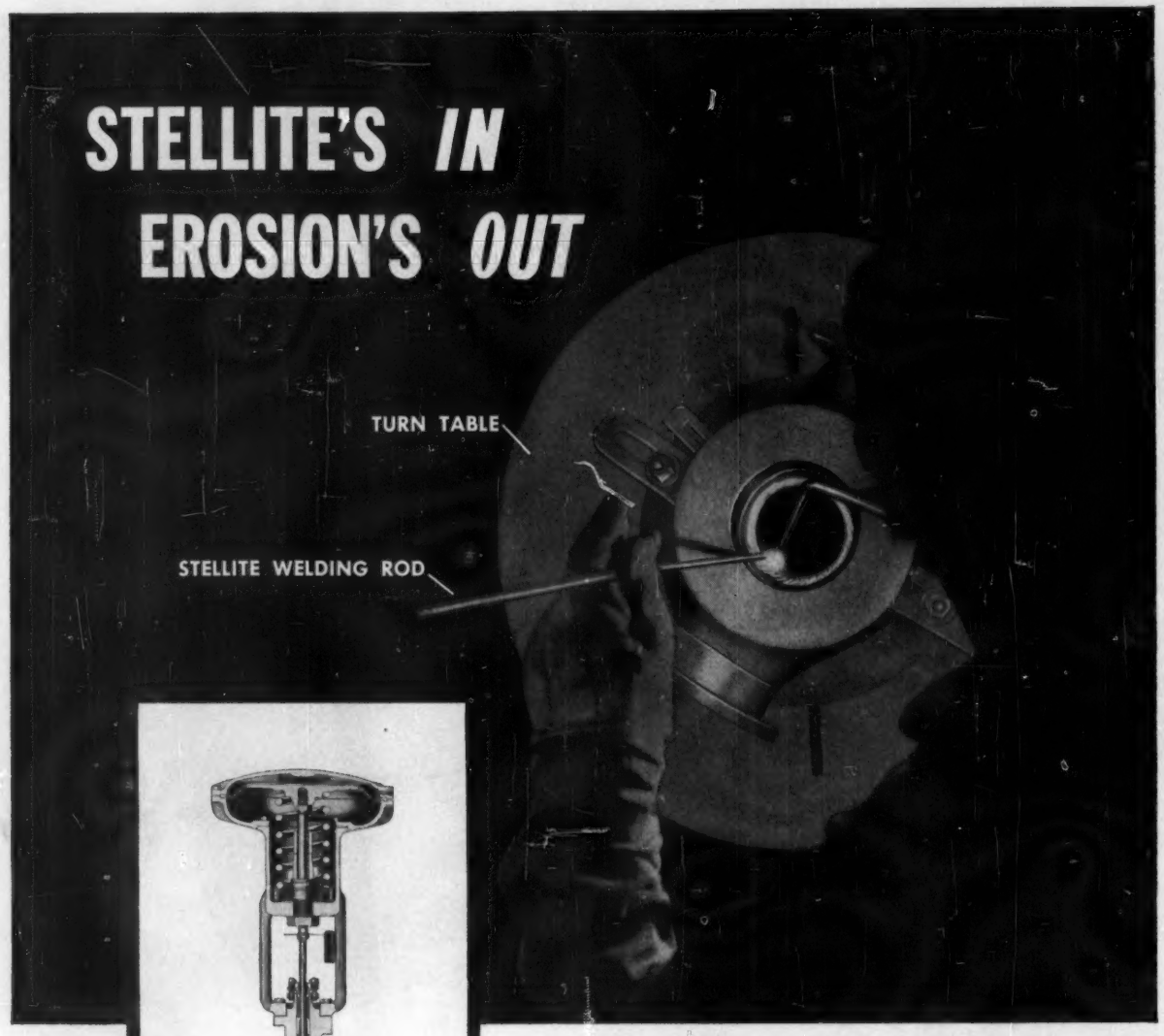

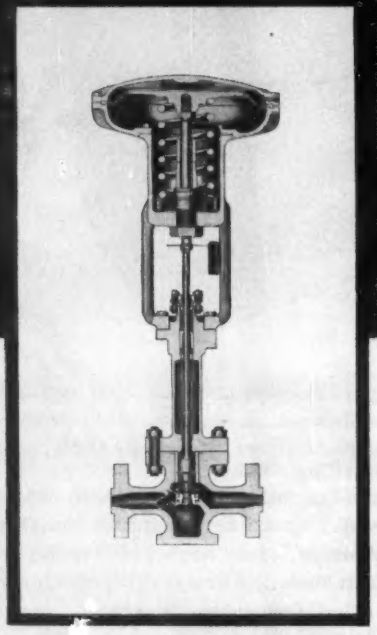

Arrow shows location of stellited seating surface in Leslie Diaphragm Control Valve for high pressure service.

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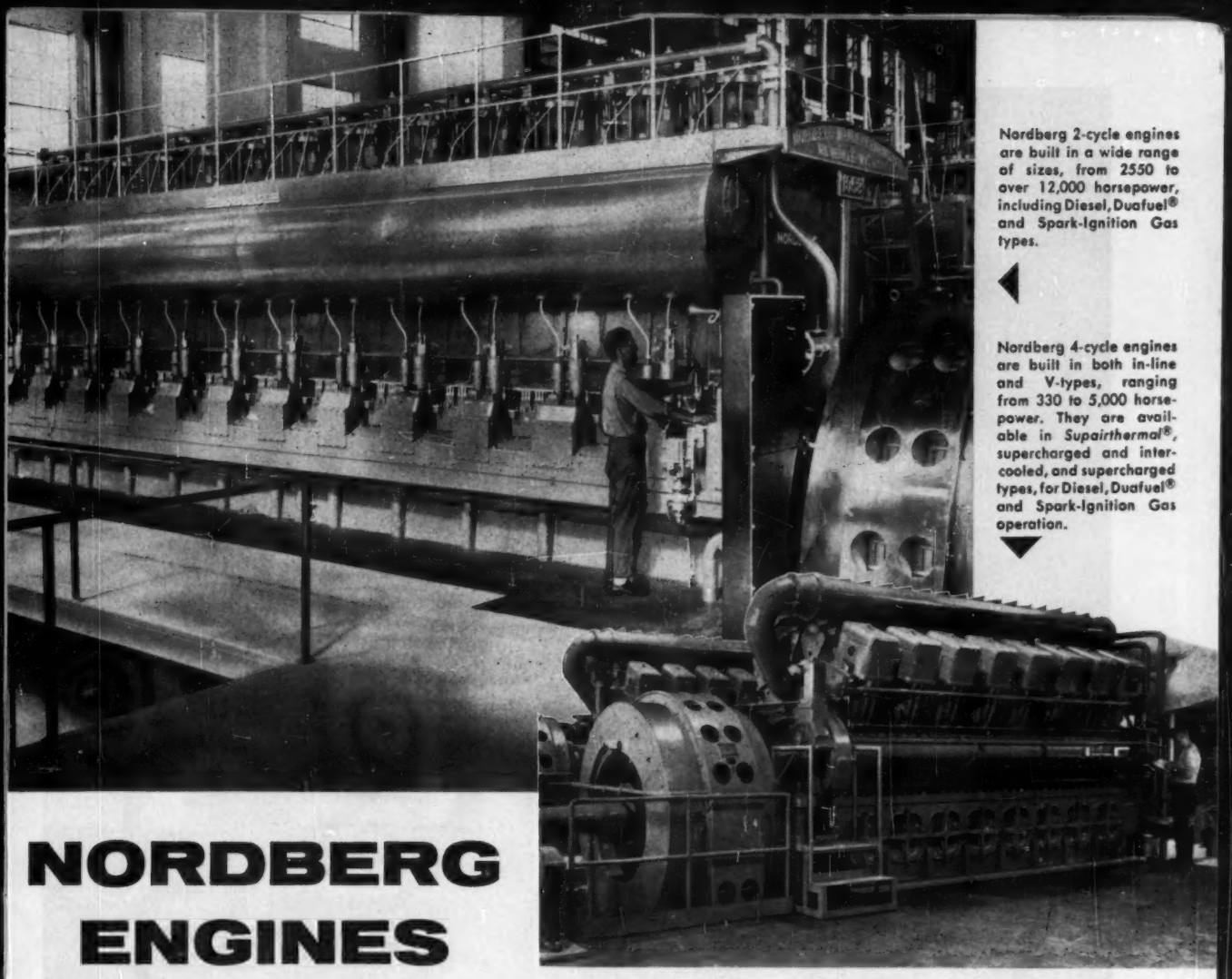

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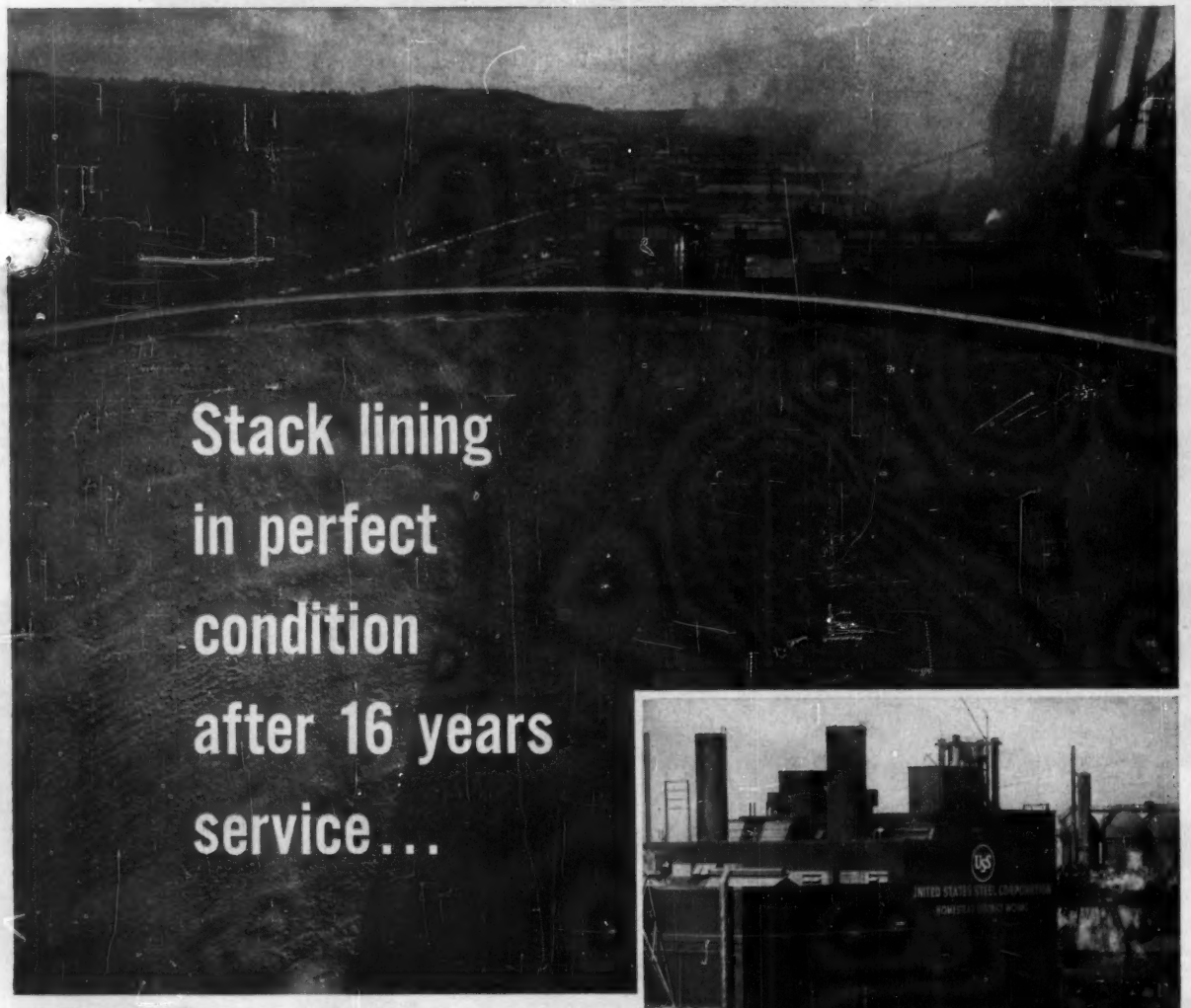

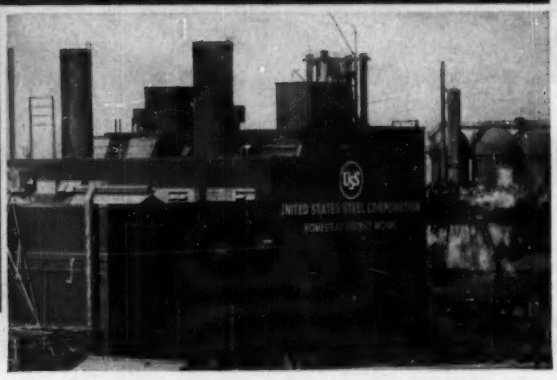

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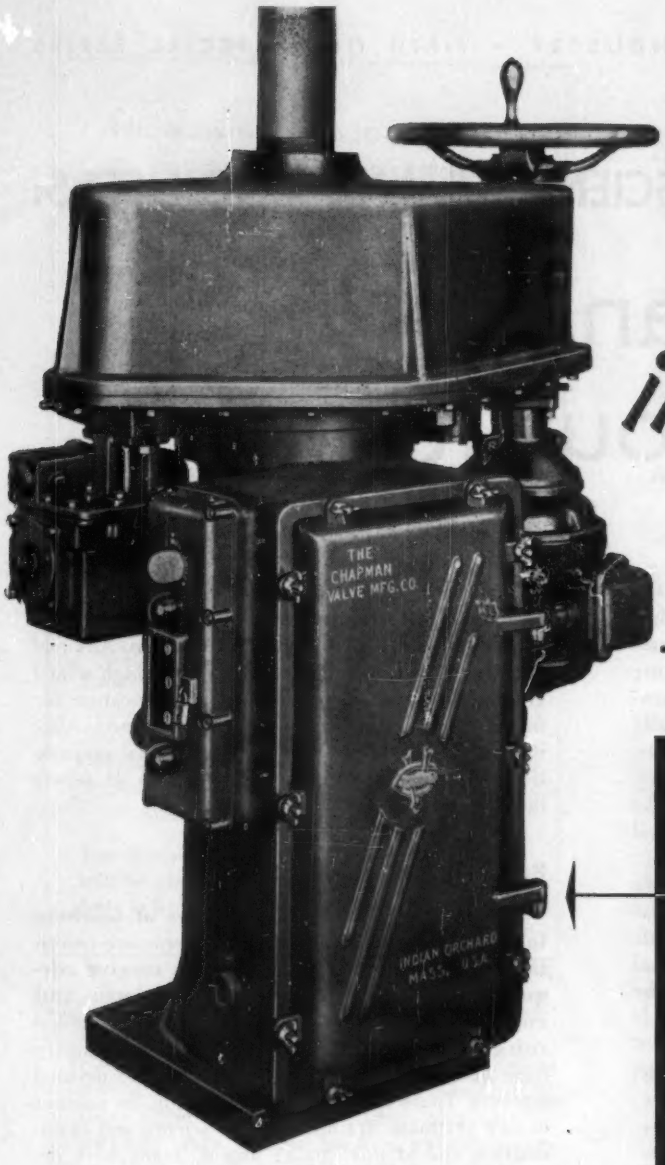

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THE SHORTAGE OF SCIENTISTS AND ENGINEERS:

What Can Be Done About It?

There is no easy or quick way to overcome the shortage of scientists and engineers that has become a threat to our national security and economic progress. The solution can come only through diligent efforts extending over several years to bring the supply of technically trained people into balance with our needs. Meanwhile, the pressure of the shortage can be relieved if industry, government and education make better use of the limited number of scientists and engineers now available.

Earlier editorials in this series have discussed the dimensions of the shortage of technical manpower, its meaning for our national security and our economic well-being and the causes of the shortage. This final editorial will survey some of the measures that can be taken to overcome the shortage. Most of the proposals presented here have been suggested elsewhere. But in combination they appear to offer the best hope of an answer to this serious national problem.

Soviet Methods Not For U. S.

It is clear that no crash program, inspired by panic and designed indiscriminately to drive hordes of high school students into science and engineering, is suitable for the United States. Even if we adopted Soviet methods of channeling a large portion of our brightest young people into technical fields, it would be at least four years before results appeared in the volume of college graduates. And such an approach would do no credit to the American way of life.

Any crash program, whether it involved totalitarian methods or simply overselling the advantages of technical careers, would be objectionable for other reasons as well. It would jeopardize the quality of scientific and engineering training. It would put many young people in fields where they have little aptitude and deny them to other fields for which they are better equipped. And, if carried too far, it might even result in the overcrowding that was feared prematurely a few years ago.

The most important problems for the long run, as the preceding editorial in this series indicated, are in the area of education. Any real solution must reduce the loss of talented high school graduates who do not continue their education for financial reasons or because of lack of interest. Also, it must improve the quality of high school preparation in science and mathematics and, above all, relieve the critical shortage of teachers.

Basic Needs in Education

Substantial increases in salaries of teachers in most of the nation's school systems are essential if high school students are to receive adequate preparation for courses in science and engineering. Pay scales that have lagged behind rising living costs and salaries available in industry have placed great strain on even the most devoted teachers. There has been a sharp drop in the number of new graduates trained to teach science and mathematics, and of this smaller number many have decided not to follow careers in teaching.

Raising teachers' salaries to more realistic levels must be primarily the job of local school districts, aided by state governments. If, in face of rapid increases in school enrollments, local and state resources prove insufficient, then federal aid will have to be considered. Higher teachers' salaries, however financed, inevitably mean higher taxes. But without appreciable improvement soon, the quality of our entire educational system is in danger.

At the college level also, financial aid is needed to provide scholarships for promising students and to increase faculty salaries. (An earlier series of editorials dealt more fully with these problems, and business aid to higher educational institutions has been mounting at a gratifving rate.)

But not all the educational problems related to the shortage of scientists and engineers can be solved with money. Science and mathematics have steadily been de-emphasized as more youngsters have gone to high school for terminal education rather

How business is helping to relieve the shortage of technical manpower

Summary of a Survey by McGraw-Hill Correspondents

- Sponsoring summer study programs for high school teachers
- Arranging cooperative work-and-study programs for students
- Sponsoring college fellowships and scholarships in science and engineering
- Paying tuition of employees taking science and engineering courses
- Keeping college faculties abreast of new developments in industry
- Hiring high school science teachers for summer and part-time work
- Giving old, but usable, laboratory equipment to schools
- Cooperating in high school science exhibits
- Sponsoring regional science fairs
- Sending speakers and training aids to schools
- Opening plants for student tours
- Analyzing jobs to relieve engineers and scientists of routine work

The McGraw-Hill Department of Economics will be glad to hear of any other ways business is helping relieve the shortage.

than for college preparation. This de-emphasis must be reversed.

Techniques of instruction, furthermore, can stand improvement at all levels of education. Professor E. P. Northrup of the University of Chicago observes: "In the past fifty years . . . there has been a revolutionary change in the character of mathematics, yet not a trace of this change is to be found in the curricula of all but a handful of secondary schools throughout the country." Colleges and universities may have to examine old fetishes about light teaching loads and small classes in order to make more efficient use of their faculties.

What Industry Can Do

Industry has the immediate problem of better utilization of available technical manpower and the long-range responsibility of helping increase our resources of trained people. Frantic recruiting practices and reckless bidding up of starting salaries—financed largely by government money for defense orders — are not the answer. There is need for earnest consideration of incentives for experienced scientists and engineers, who too often must look to sales or executive positions for adequate financial recognition.

Industry in many instances could make more efficient use of engineers and scientists by shifting work to technicians, clerical personnel and even machines. One company found that 15% of the time of an engineering design group was spent on routine jobs and that this valuable time could be saved by adding a technician and a clerical worker to the group.

Other potential sources of technical manpower could be tapped more extensively to relieve the shortage. Very few women have entered what has been traditionally a man's world. Negroes are only slowly gaining educational and employment opportunities in technical fields. And many experienced older men can still give useful service.

A Good Beginning

Much is being accomplished already in efforts to attract more young people into scientific and engineering careers. A summary of some of the things business is doing is presented above. Other notable contributions are being made by such organizations as the professional engineering and scientific societies (especially through their manpower commissions), the National Science Foundation, the National Research Council, the National Education Association, the National Merit Scholarship Foundation and the Thomas Alva Edison Foundation.

Results are beginning to appear in rising enrollments in engineering schools and technical institutes. Between 1951 and last year, according to McGraw-Hill's annual survey of technical institutes, enrollments in these schools rose from 46,000 to a record 67,000. Engineering enrollments rose in the same period from 166,000 to 243,000. A rising tide of graduates is already being made available to American industry.

This is a good beginning. But only with wider appreciation of the serious implications of the shortage of scientists and engineers and intensified efforts on the part of business, government and education to relieve the shortage can we hope to overcome this threat to our national security and economic well-being.

This is one of a series of editorials prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments of particular concern to the business and professional community served by our industrial and technical publications.

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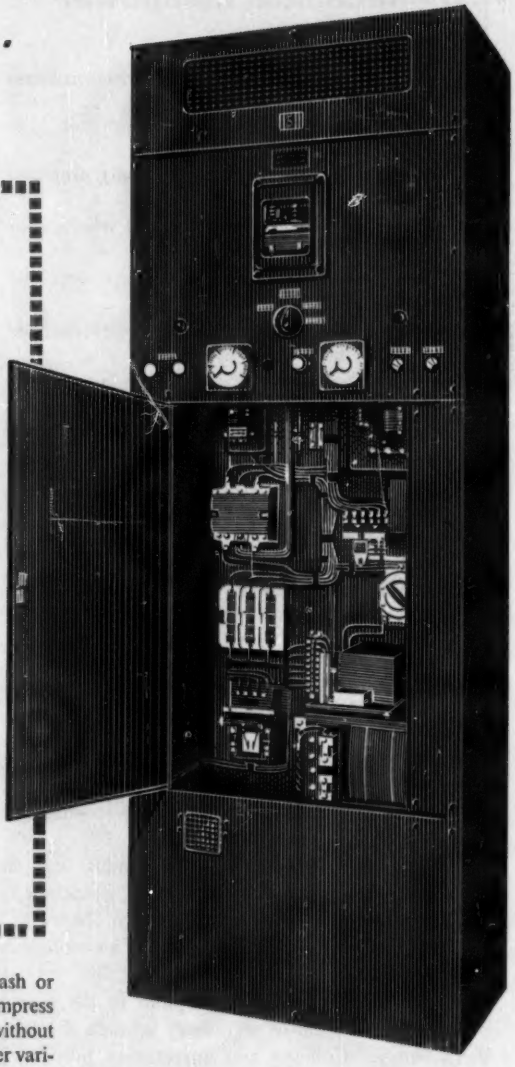

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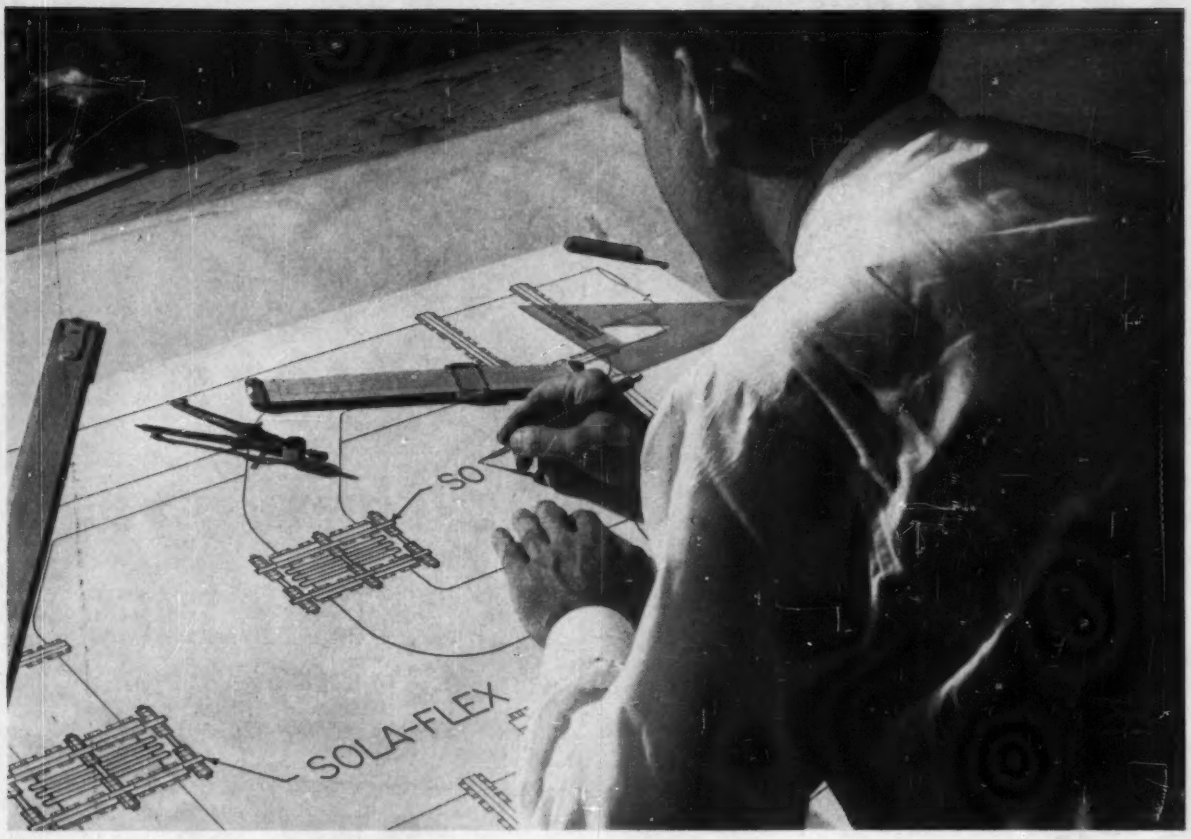

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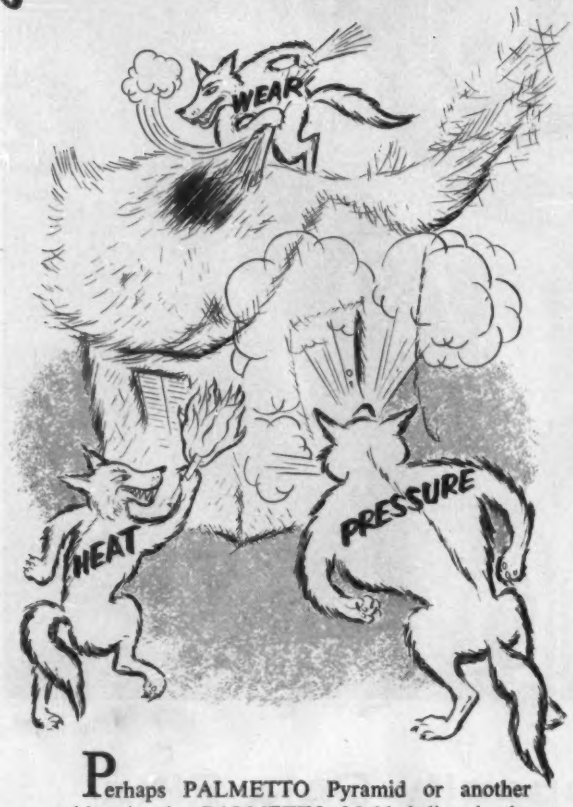

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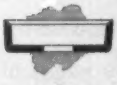

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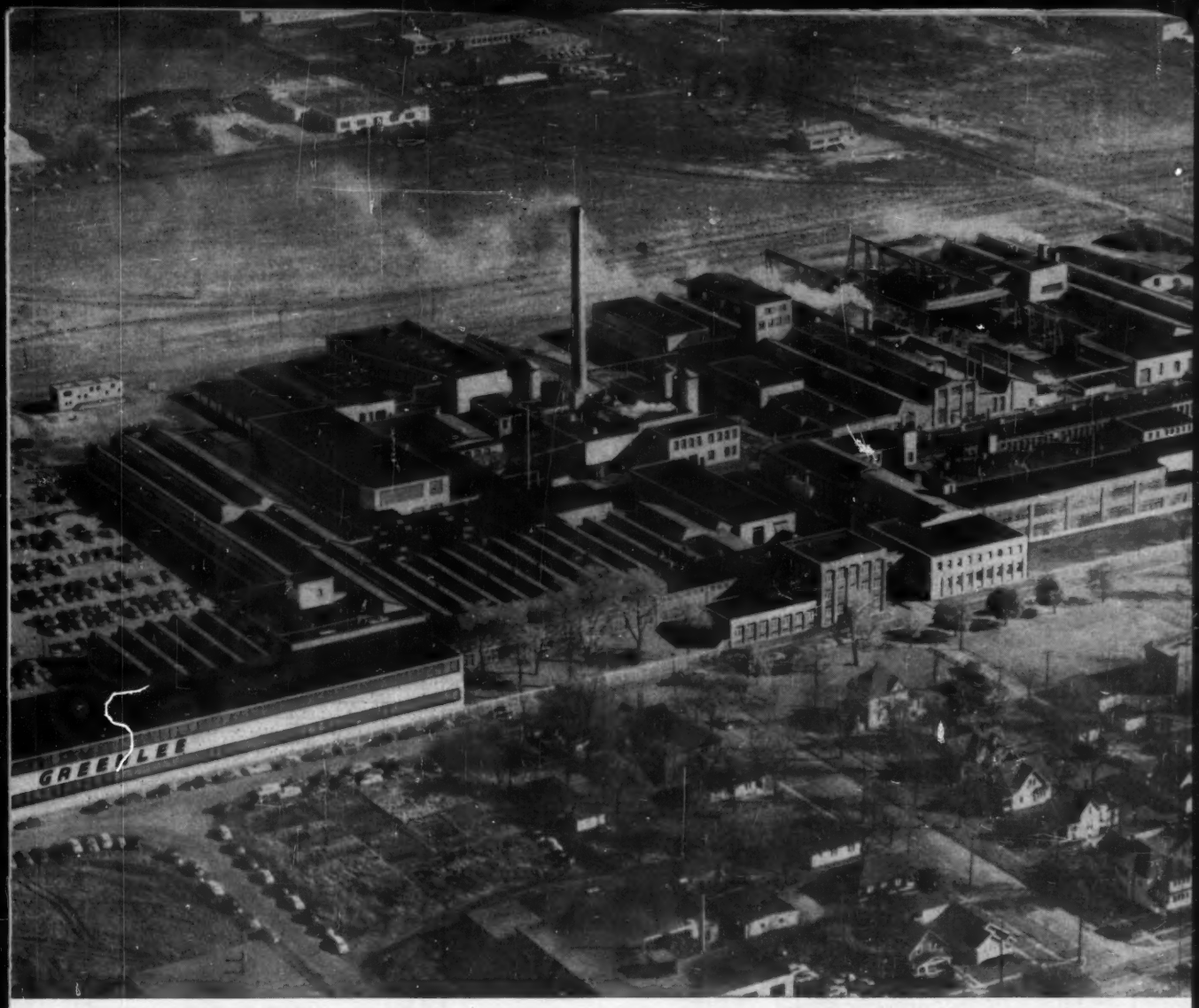

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Please send resume of training and experience to:

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OPPORTUNITIES WILL BE GREAT SINCE WE INTEND TO EXPAND THE DEPARTMENT...

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Diesel Generator Sets • Stationary • Portable • Mobile Motors and Generators

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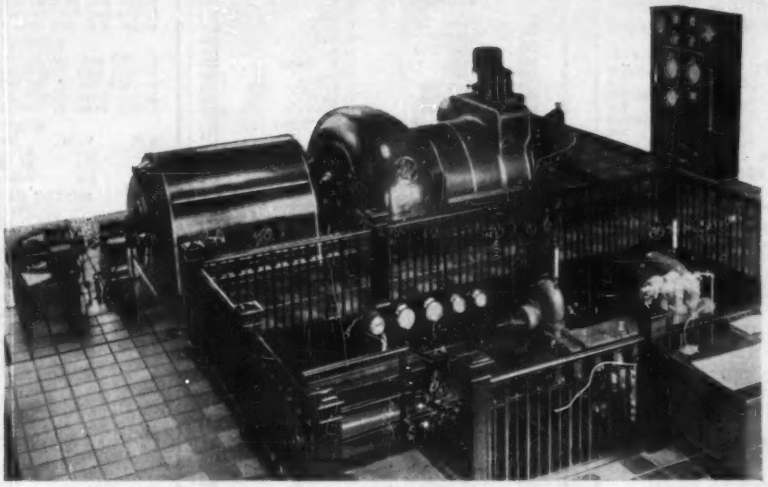

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1—50 HP General Electric, Series WD., 600 RPM 500 Volt DC, with electric brake
1—25 HP Westinghouse, CP, WD., Type SK, 550 Volt DC, 600 RPM
1—15/25 HP General Electric, CP, WD., Type RC, 400/600 Volt DC, 1500 RPM
1—15 HP General Electric, SR, WD., Type CVC, 550 Volt, 1350 RPM

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(550 Volt DC Motor Driven)

1—500 Amp (30KW) General Electric, CP, WD., Type RMC-12, 60 Volts DC, Driven by 45 HP General Electric Motor, SH. WD., Type RC-33 550 Volt DC, 1200 RPM
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1—300 Amp Westinghouse, Type CF-3, 40 volts DC, 1500/1900 RPM, Motor, Westinghouse Type SK, SH. WD., 400/800 Volts DC, 1500/1900 RPM

MOTORS—SYNCHRONOUS

(3/60/2300)

1—250 HP General Electric, Type TS, Form AL, Frame 7644, RPM 720
1—250 HP General Electric, Type ATI, Form B, RPM 600
1—200 HP General Electric, Type TS, Form BL, Model 5G883, Frame 7558, RPM 900
1—150 HP General Electric, Type TS, Form BL, Model 5G323, Frame 7556, RPM 900

MOTORS—SLIPRING

2—300 HP Westinghouse, Type CW, 3/60/4000 (2300), 1760 RPM
1—250 HP General Electric, Type MT, 3/60/2200 (440), 700 RPM
1—250 HP General Electric, Type I-M, 3/60/2300, 450 RPM
2—200 HP General Electric, Type I-M, 3/60/4000 (2300/440) 1800 RPM
2—200 HP Westinghouse, Type CW, 3/60/2300 (440), 580 RPM
1—200 HP General Electric, Type I-M, 3/60/440, 450 RPM

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2900 BRIGHTON BLVD., DENVER, COLORADO

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3 15,000 KVA G.E. H-DHJ
1/60/132,000Y x 13,800
8.5% IMP. 4 taps above & below

Automatic tap changing on the load
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Excellent condition; very low price F.O.B. Milwaukee

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COMBINATION MILL DRIVES — 15/2500 HP
D.C. MOTORS WITH M.G. SETS & CONTROLS

Qu.		MAKE	TYPE	VOLTS	R.P.M.
1—	2200 HP	G.E.	MCF-12	600	400/500
	23001KW	G.E.	Syn.	2300/4600	514
1—	1250 HP	G.E.	MCF	600	600/750
	1000 KW	G.E.	Syn.	2300/4600	720
1—	1000 HP	G.E.	MCF-8	600	350/700
	1000 KW	G.E.	Syn.	2300/4160	720
1—	225	Whse.	SK-185	375	950/1200
1—	200 KW	Whse.	Sq. Cage	440	1200

ALSO MANY OTHER COMBINATIONS

A. C. MOTORS—3 Ph. 60 Cy.

SLIP RING

Qu.	H.P.	Make	Type	Volts	Speed
2	1750	G.E.	M-579BS	4800/2400	1500
1	1500	G.E.	MT	6600	257
1	1500	G.E.	MT	6600	1187
1	1100	F.M.BB	SF806S	4800/2400	1800
1	1000	A.C.	Mill	2300	240
1	800	G.E.	MT	2300	292
1	750	G.E.	MT-573	2200	1190
1	700	Al. Ch.	D.P.	2300	500
1	500	Whse.	CW	550	350
1	400	Whse.	CW	440	514
1	400	Whse.	CW-1218	2200	435
1	250	G.E.	IM-17A	440/2200	720
1	250	G.E.	MT-424Y	4000	257
1	250	A.C.		550	600
1	200	G.E.	IM	2200	580
1	150	Whse.	CW30E17	2300	435
2	125	A.C.	ANY	440	865

SQUIRREL CAGE

1	800	G.E.	KT-573	2200	1190
2	650	G.E.	FT-559BY	440	3570
2	450	Whse.	CS-1420	2300/4150	354
1	400	G.E.	1E-15B	2300	1165
1	400	G.E.	IK	2200	580
1	200	G.E.	IK-17	440	580
3	200	G.E.	KT-557	440	1800
1	150	Whse.	CS	440	580

SYNCHRONOUS

1	7000	G.E.	ATI	2240/6600	600
1	4250	C.W.	3501-SL	13800/6900	514
2	1750	G.E.	ATI	2300	3600
1	1750	G.E.	TS	2300	900
2	2000	Whse.		2200	120
1	1100	G.E.	ATI	2300/4600	900
1	500	G.E.	TS-756Y	2200	1200
2	350	G.E.	TS	2200	150

M-G SETS—3 PH. 60 CY.

Qu.	K.W.	Make	RPM	DC Volts	AC Volts
1	3000(3U)	G.E.	514	600	4000/6600/ 13200
2	2000/2400	G.E.	450	250/300	2300/4600
1	2000	G.E.	500-25cy	600	11000
2	2000	G.E.	514	600	4600/2300
1	1750/2100	G.E.	514	250/300	4800/2400
1	1500	G.E.	720	600	6600/13200
1	1500	G.E.	514	250	2300/4600
1	1000	G.E.	900	260	6600
3	1000	G.E.	720	600	6600/13200
1	750	G.E.	720	275	6600/13200
1	750	G.E.	720	125/250	2300/4600
1	500	Whse.	900	125/250	440
1	150	Whse.	1200	600	2300
1	150	Whse.	1200	275	2300

WELDING M.G. SET

Gen. Elec.—1100 Kva 0.7 p.f.—2300/4600 V. 3/60
Generator with 1750 Kva—.8 p.f.—2300 V. 3/60 motor complete with exciter set and controls.

TRANSFORMERS

Qu.	KVA	Make	Type	Ph.	Voltage
1	3000	A.C.	OISC	3	23000x2400/4160
1	2500	Al.Ch.	OISC	3	34500x13800
1	2500	Al.Ch.	Fur.	3	13200x147/113
3	1000	G.E.	OISC	1	13800x228/460
2	500	G.E.	RID	1	4800/2400/480
3	500	Kuhl	OISC	1	13800x2400
3	333	G.E.	H	1	6900x230/460
3	333	G.E.	OISC	3	4160/480/270Y
3	250	L.M.	OISC	1	14400/12000/240/120

FREQUENCY CHANGER SETS

Qu.	KW	Make	Freq.	Voltage
1	5000	G.E.	60/50/60	6600/11000/6600
2	2500	G.E.	25/62.5	2300/2300
1	1000	G.E.	25/58.3	4400/2300
1	500	Al. Ch.	25/60	11000/2300

TURBO GENERATORS

Qu.	KW	Make	Desc.
1	4000	G.E.	Condensing 425 — 750 F.T.T. Surface Condenser 3/60/2300/ 4000 V Direct con exciter.
1	1500	Whse.	Auto extraction 150 lbs. — 600° F.T.T. 60 lb. extraction 3/60/240 V. Dir. Conn. Exc.
1	1000	Moore	Auto-Ext. Cond 175/200 # U.S.P. 5/20# G. Ext. Surface Condenser—3/60/2300. Non-condensing 175/200 lbs. I.S.P. 5/20 lbs. G.E.P., 450/ 3/60.

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37 Years Dependable Service

SLIP RING MOTORS 3-Ph., 60 Cy.

H.P.	Volts	Make	Speed
800	2300	Whse.	900
500	4000/2300	G.E.	600
450	440	Whse.	514
400(2)	2300	G.E.	900
400	2200	Whse.	450
300	4000/2300	G.E.	720
300	440	G.E. (hoist)	600
300	440	Whse.	3600
250	2200/440	G.E.	1200
250	440/220	Whse.	600
250	550/440	G.E.	1200
225	4000/2300	G.E. (hoist)	600
200	440/220	Whse.	514
200	2200/440	G.E.	600
150	440/220	Whse.	720
150	2200/440	G.E.	600
125	2300	G.E.	600

SYNCHRONOUS MOTORS 3-Ph., 60 Cy.

H.P.	Volts	Make	Type	R.P.M.
400	2200/440	G.E.	ATI	720
375	2200	Whse.	G	900
350	440/220	El. Machy.	Syn.	1200
300	2300/460	G.E.	TS	720
300	2200/440	G.E.	TS	1200
250	440/220	G.E.	ATI	600
150	440/220	G.E.	TS	720
125	440/220	Whse.	HR	600

SQUIRREL CAGE MOTORS

H.P.	Volts	Make	Type	Speed
600	2200	G.E.	FT	3600
500	2200/4000	Elliot	SC	1800
250	440	G.E.	KT	1200
300(2)	2200	G.E.	FT	3600
300	2300/4000	L. Allis	FS	1800
250	440/220	G.E.	KT	720
250	2300	Whse.	CS	600
200	440/220	G.E.	KT	1800
200	2200	G.E.	KT	1800
150	2300	Al. Chal.	AR	1800
150	440/220	G.E.	KT	720
150	2300/440		KT	600
150	2200/440	G.E.	FT	1200
125(2)	2300/440	Whse.	X-proof	720
125	2200/440	G.E.	K	600
100(2)	4000/2300	L. Allis	OX	1200

A. C. GENERATORS

1—320 kva, 660 rpm 2300/440/220 V., G.E.
1—300 kva, 900 rpm, 2200 V., Whse.
1—225 kva, 60 rpm, 220/440 V., G.E.
1—200 kva, 720 rpm, 2200/440 V., G.E. (Ball)
1—187 kva, 1200 rpm, 2200/440 V., Whse.

CIRCUIT BREAKERS

2—2000 amp. GG E., 2 pole, 600 V.
2—1600 amp. ITE, 2 pole, 600 V.
6—FKR-165-28, 600 amp., 15,000 V. G.E.
1—400 Amp., Condit, 3P. 25 KV outdoor
1—400 Amp., R. Smith, 3P. 7.5 KV outdoor

D. C. MOTORS

H.P.	Volts	Make	Type	Speed
225	230	Whse.	SK	1800
150	230	El. Dyn.	B/brg.	600
150	230	Whse.	SK	1750

MOTOR GENERATOR SETS

KW	Make	Input V., AC	Motor Type	Output V., DC
250	Whse.	2200	Syn.	250
150	Whse.	440/220	Sq. Ca.	275
125	G.E.	4000/440	Syn.	125
75	Cr. Wh. (unused)	440/220	Sq. Ca.	240/120
65	G.E.	2300/440	Sq. Ca.	250

TRANSFORMERS 60 Cy.

1—1000 kva, Whse., 13,800—2300 V., 3 ph., New
1— 600 kva, Standard, 13,800—2300 V., 3 ph.
3— 500 kva, G.E., 13,800—2300 V.
3— 333 kva, G.E., 13,800—2300 V.
3— 333 kva, G.E., 2400—480 V.
2— 300 kva, G.E., 4150—240 V., 3 ph., Pyr.
3— 200 kva, G.E., 2400—120/240 V.
3— 200 kva, Mol., 13,800—2300 V.
3— 150 kva, Al. Ch., 2400—220 V.
3— 150 kva, Al. Ch., 440-220 V., dry, New
3— 100 kva, Al. Ch., 440-220/110 V., dry, New

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3750-KVA. ELLIOT, 440#, 750°F., Cond., 2300/ 4160-V. New, 1940.

3125-KVA., 250/300#, 750°F., Aut. Extr. 50# Cond. New, 1942.

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Size C-150-150H 100 lbs. pressure

Direct Synchronous Motor Driven with regulators, intercoolers, air-maze filter, silencer, Manzel mechanical lubricators, aftercoolers, essential piping, valves, air receiver.

Motor Control: GE Limitamp Synchronous motor starters, 400 amp ITE 5 KV interruptive switch.

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We carry a large stock of rebuilt and guaranteed transformers, and invite your inquiries.
Custom-built transformers and coils manufactured to your specifications.
Expert Repair Service—all makes and sizes of transformers rewound, repaired and redesigned. Ask for our price schedule.

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40 Years' Dependable Service

SPECIALS

5000 KVA TURBO GENERATOR, condensing, 450 PSI.

200 KW MG SET, 250 Volts DC, 2300/3/60, with panels.

6300 sq. ft. CONDENSER.

700 HP Ideal Synch. MOTOR 4150/2400, 514 RPM & panel.

628 CFM TYPE ES1, I.R. COMPRESSOR 100 PSI, 100 HP Motor.

BOILERS

153 HP UNION WATER TUBE, 160 PSI.

250 HP B&W, 150 PSI.

4' x 135' STEEL STACKS.

70,000 LB. HEINE, 400 PSI.

80,000 LB. ERIE, 250 PSI.

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HEAT & POWER CO., INC.

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Murray Hill 7-5280

(Machinery & Equipment Merchants)

Thousands of Motors & Generators IN STOCK.

EVERY MACHINE COVERED BY THE WAGNER GUARANTEE

D. C. MOTORS

HP	Mfr.	Type	Volts	Speed
300	Allis Ch. b.b.	EW	350	1000
200	Reliance	1400-T	230	850
200	Gen. Elec.	CDM-173	230	1800
175	Cr. Wh.	151-H	230	500
150	Whse.	SK-184	230	850
100	Reliance	651-T	550	1000/1600
100	Reliance	651-T	230	575/1150
100	G.E. dynamom.	TLC-50	230	1000/4000
75/150	Whse.	SK-200	230	400/1000
75	Century	H-92	230	600/1350
75	F. Morse b.b.	DH-140	115	1600
60	Allis Ch.	E-140	230	1150
50	G.E. (3)	CD-125	230	400/1200
50	G.E. b.b.	CD-92	230	3500
40	Reliance b.b.	131-T	550	1750
30	Imperial b.b.	D-69	230	400/1600

MOTOR-GENERATOR SETS

KW	Mfr.	Input V	Output V.
300	Gen. Elec.	2200/440 AC	260 DC
200	Whse.*	220/440 AC	55 DC
200	Gen. Elec.*	220/440 AC	125 DC
200	Whse.	2300 AC	250 DC
175	Gen. Elec.	220/440 AC	250 DC
125	Gen. Elec.*	2300/4000 AC	250 DC
100	G.E.*	2200/440 AC	125 DC
100	Whse.	220/440 AC	250 DC
75	G.E. converter	440 AC	250 DC
75	G.E.	220/440 AC	125 DC
60	Whse.	220/440 AC	250 DC
50	Gen. Elec.	220/440 AC	125 DC
35	Gen. Elec.	220/440 AC	125/250 DC

D. C. GENERATORS

KW	Mfr.	Type	Volts	Speed
300	G.E. (2)	CY-275	260	1200
250	Allis Ch. b.b.	EW	350	1200
200	Reliance	1400-T	250	1200
150	Whse.	SK-184	230	1150
150	Cr. Wh.	CCD	250	850
100	Whse.	SK-180	250	900
100	Allis Ch.	E	125	1200
100	Reliance	651-T	600	1200
75	Whse. b.b.	SK-163	125	1000
60	Allis Ch. (3)	E-146	250	1500
40	Gen. Elec.	RC	250	1750

A. C. MOTORS — 60 CYCLE

HP	Mfr.	Type	Volts	Speed
700	G.E.	Slipring	220/440	1800
600	G.E.	Slipring	2300	600
500	Whse.	Slipring	2200	450
450	Allis Ch.	Synch.	480	400
400	Whse. (2)	Synch.	2200	1800
400	Whse.	Sq. Cage	2200	514
400	Marathon (2)	Sq. Cage	2200	3600
400	Whse.	Sg. Cage	2200/440	1200
350	G.E.	Sg. Cage	2200	1800
300	El. Mchy (2)	Synch.	2200/440	360
300	Whse.	Synch.	440	1200
300	G.E.	Slipring	440	450
300	Allis Ch.	Sq. Cage	2200/440	720
250	G.E.	Slipring	440	1200
250	G.E.	Sq. Cage	2200/440	1200
250	Gen. Elec.	Sq. Cage	440	3600
250	G.E.	Slipring	220/440	720
250	Gen. Elec.	Synch.	220/440	450
250	Whse.	Slipring	440	1200
250	G.E.	Sq. Cage	2200	1800
250	Allis Ch.	Synch.	440	360
225	G.E.	Synch.	220/440	900
200	G.E. b.b.	Sq. Cage	2200/440	1200
200	Whse. (2)	Slipring	2200	514
200	Reliance b.b.	Sq. Cage	220/440	1800
200	Allis Ch.	Slipring	440	450
200	Gen. Elec.	Sq. Cage	220/440	720
200	Cr. Wh.	Sq. Cage	220/440	3600
200	Whse.	Sq. Cage	2200/440	900
200	G.E. (2)	Sq. Cage	2200	514
175	G.E. (2)	Synch.	220/440	720
150	El. Mchy.	Synch.	220/440	360
150	G.E. (4)	Slipring	2200/440	600
150	G.E. (2)	Sq. Cage	2200/440	720
150	Cr. Wheeler	Sq. Cage	220/440	450
150	G.E.	Slip Ring	220/440	450
125	Whse. TEFC	Sq. Cage	2200/440	720
125	G.E. TEFC	Sq. Cage	220/440	3600
125	Ideal	Slipring	4000/2200	600
100	Whse. TEFC	Sq. Cage	220/440	1200
100	Whse. (2)	Sq. Cage	2300	600

TRANSFORMERS—6—167KVA Allis Ch. dry type, 1 ph. 60 cy. 2400/4160—240/480V., like new.

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4 horizontal, 14 vertical, Westinghouse

Driving forced draft blowers—capacities ranging from 39000 to 56000 CFM and 16" to 24" pressure. Steam pressures 360 to 575#, back pressure 10#.

Will sell turbines separately if desired. *Price reasonable.*

Also—1—250 KW GE turbo generator unit, 3 phase, 60 cycle, 440 volt. Used one year.

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FOR SALE

5—OIL CIRCUIT BREAKERS

Whse. late type, outdoor type, De-Ion Grid, T.P.S.T., Rated 161000 V., 1200 amps., 60 cy., 3 ph., Type GO-3, Interr. Duty 1,500,000 KVA.

Fully complete—Cond. like new.

Price and further inf. upon request.

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B & W BOILER

66500#-Hr., 650#, 750°F. 4-DRUM STERLING TYPE. Complete in all Respects.

CHARLES WEAVER, M.E.

19701 JAMES COUZENS HIGHWAY

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4600 KW GENERATOR

GENERAL ELECTRIC, TYPE ATB-2, 3 PHASE, 93-1/3 CYCLE, 2700 VOLTS, 5600 RPM, (ALSO 3/60/1700V at 3600 RPM.) USED.

EASTERN SCRAP & SALVAGE CORP.

65 Muirhead Ave., Trenton, N. J.

Phone—Owen 5-6351

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E. Keeler Steam Generating Boiler CP Type

Rated 300-horsepower—will develop 23,000 pounds per hour.
2546 sq. ft. of heating surface.
454 sq. ft. water wall heating surface.
160# maximum steam working pressure—arranged for heavy oil firing.

Completely equipped with National Air Oil steam atomizing reverse firing burners, oil flow meter, gauges, reduced draft fan with stack, blowdown valves, dual oil preheater set with steam and electric fuel oil pumps, strainers, gauges steam pressure reducing valves etc.

Two steam boiler feed pumps (Union Steam Co.) either of which will develop full rating of boiler.

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STEPHEN-LEEDOM CARPET CO., INC.

Beaver Street

Bristol, Pennsylvania

Rebuilt HEMPHILL Guaranteed EQUIPMENT

TRANSFORMERS—60 CYCLE

Qu	KVA	Make	Type	Phase	Voltages
2	750	G.E.	H	1	4800-120/240
1	750	G.E.	HT	3	4150Y-220/440
2	250	G.E.	H Pyranol	1	2400-4800/8320Y-120/240
2	250	West.		1	2300/4600-230/460
3	200	G.E.	H-KD	1	13800/13420/4600-240/480
3	200	G.E.	H	1	7800/15600-230/440
1	150	Eisler	OA	1	4160-240/480
3	150	West.	S	1	2400/4160-460/230/115
3	50	G.E.	HS	1	2400/4160-240/480
2	37½	West.	Hypersil	1	2400/4160-240/480
1	25	G.E.	H Pyranol	1	2400/4160Y-120/240
6	15	Maloney	KL	1	2400/4160Y-120/240

SYNCHRONOUS MOTORS

Qu	HP	Make	Speed	Type	Volts
1	100	G.E.	900	TS	2300
1	125	G.E.	600	TS	2300
1	125	E.M.	900		4000
1	150	G.E.	1800	TS	220/440
2	150	Allis-Ch.	360		2300
1	150	West.	900		220
1	300	E.M.	720	TEFC	2300
1	500	West.	450	HR	440
1	1000	West.	360	Mill	2300/4150

SLIP RING MOTORS

Qu	HP	Make	Speed	Type	Volts
1	15	G.E.	900	MT-542	440
1	25	G.E.	900	MT-526	440
1	60	G.E.	1800	MT	220
1	60	Ideal	900	AV	220
1	75	G.E.	600	IM	440
3	150	Allis-Ch.	1800	AY RW	2300
1	200	West.	514	CW	440
1	250	West.	600	CW	440
1	350	West.	1800	CW	2300
1	500	G.E.	1200	M	2400/4150

SQUIRREL CAGE

Qu	HP	Make	Speed	Type	Volts
1	40	Wagner	1750	CP TEFC	220/440
2	30	Wagner	1160	CP TEFC	220/440
1	25	G.E.	1170	405TEFC	220/440
1	25	Howell	1170	405TEFC	220/440
1	75	G.E.	1800	K-4459	440
1	100	West.	1160	CS	440
1	150	G.E.	720	KT-562	440
2	250	G.E.	1790	K.-T.E.F.C.	2300
1	275	G.E.	1200	KT559BS	2200
2	300	G.E.	1800	K-4150V	new

MOTOR GENERATOR SETS

Qu	K.W.	Make	Speed	Volts DC	Volts AC	
1	30	G.E.	1800	125	220/440 V.	
3	60	E.M.	1200	125	220 v. Syn.	
1	75	G.E.	1800	250	480 v. S.C.	
1	150	GE. Wh.	600	125	220/440	
1	175	West.	1200	125	4150 Syn.	
1	300	G.E.	1200	250	2300/4160Y	S.R.
1	1000	West.	720	600	2300/4160Y	

D.C. 230 VOLT MOTORS

Qu	HP	Make	Speed	Type
1	75	C.W.	900	WP
1	125	G.E.	1700	RC
2	150	C.W.	900	WP
1	250	Allis Ch.	1750	EBL149 BB

A.C. HOIST MOTORS

Qu	HP	Make	Type	Speed	Volts
1	25	G.E.	MTC	585	440
1	200	G.E.	ITC-8617	600	440

FOR POWER
J. L. HEMPHILL & CO.
1603 54th STREET, NORTH BERGEN, N. J.
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COMPRESSOR DIRECTORY
World's Best Rebuilts

95 CFM	1500 PSI	6½-3⅞x1⅝x7	Chicago TCB3
138 CFM	100 PSI	7x7	Ingersoll ESI
203 CFM	300 PSI	9-4¾x9	Penn AT2
234 CFM	100 PSI	9x9x9	Chicago St. (new)
268 CFM	500 PSI	10-4½x10	Ingersoll XOB
343 CFM	500 PSI	11-5x13	Worth. (new frame)
464 CFM	100 PSI	12x11	Gardner RX
552 CFM	100 PSI	13-8"12	Ingersoll XRB
502 CFM	125 PSI	12x13	Chic T
676 CFM	100 PSI	15-9½x12	Worth
1546 CFM	100 PSI	21-12½x14	CP—OCE 250 HP Syn 3-60-2300 .8 PF
1600 CFM	40 PSI		Fuller Rotary—Syn.
1728 CFM	110 PSI	140 lbs. at	Ingersoll XPV
2018 CFM	Vacuum	28x11	Ing ES

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DIESEL SALES & SERVICE
Complete Switchboard Design & Construction
GENERATORS—GAS OR DIESEL
USED & REBUILT EQUIPMENT
UNIVERSAL POWER ENGINEERING CO.
217 Colden St., Jersey City, N. J.
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3500 KW MG SETS

5—3500 KW, 3 Unit, Allis-Chalmers, Motor Generator Sets. Each consisting of:

2—1750 KW, 250/350 Volts parallel, 500/700 Volts series, 514 RPM, 500 Amp, Type HCC, rated continuous at 40 Deg. C. Allis-Chalmers DC Generators with Class B Insulation, separately excited, direct connected in the center to:

1—5000 HP, 3730 KW, 13800 Volts (6900 Volts), 3 Phase, 60 Cycle, 514 RPM, 162 Amps, Allis-Chalmers, Synchronous Motor with Class B Insulation, rated continuous at 40 Deg. C. Rise.

The Motor Generator Set is equipped with a 40 KW 514 RPM, 250 Volt, DC Exciter and a 10 KW, 514 RPM, 250 Volt, Allis-Chalmers DC Exciter.

All mounted on a structural steel base approximately 27' long x 11' wide.

These Units are of the very latest type and desgn—condition excellent—were used only a short time—AC and DC Switchgear available.

For any additional information and price, please contact one of the following dealers closest to you:

MOORHEAD ELECTRICAL MACHINERY CO., 120 Noblestown Rd., Oakdale (Pittsburgh District), Pennsylvania.

BRAZOS ENGINEERING CO., INC., P.O. Box 9114, Houston, Texas

DUQUESNE ELECTRIC & MFG. CO., 6428 Hamilton Avenue, Pittsburgh 6, Pa.

T. B. MacCABE COMPANY, 4300 Clarissa Street, Philadelphia 40, Penna.

3 NEW BOILERS

Available at fraction of new cost

BABCOCK & WILCOX single uptake controlled superheat marine type express boilers, 3 drums, with economizers.

Designed pressure	634 lbs.	Steam temperature	850°F
Operating pressure	550 lbs.	Furnace volume	1473 cu. ft.
Superheated steam	221,000 lbs./hr.	Total generating surface	9338 sq. ft.
Saturated steam	32,000 lbs./hr.	Superheater surface	1620 sq. ft.
Full power total	253,000 lbs./hr.	Economizer surface	3843 sq. ft.

NOTE: These boilers are new and complete. They are erected and ready for use and should therefore be considered only for such places as can be reached by water transportation.

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DIESEL GENERATOR SETS

2—McIntosh-Seymour (Alco) 950 HP 8 cyl. 225 RPM, 875 KVA Westinghouse 3 phase, 25 or 60 cycle alternators. 20 KW exciters.

1—McIntosh-Seymour (Alco) 600 HP 5 cyl. 225 RPM, 500 KVA General Electric 3 phase, 25 or 60 cycle alternator. 15 KW exciter.

Complete plant installation with all accessories. Priced attractively. With or without generators.

MISSISSIPPI VALLEY EQUIPMENT CO.
507 Locust St. • St. Louis 1, Mo.

TURBO-GENERATORS

2500 KW G.E. Non-C. 3/60/2400/4160 V 3600 RPM 185 PSIG 30° BP

2000 KW Allis, Cond. 3/60/2400 V. 3600 RPM 400 PSIG 600° TT

1000 KW G.E. Cond. Extr. 3/60/480 V 3600 RPM 225 PSIG 20° extr.

Full line power equipment

BREW, WOLTMAN & CO., INC.
50 Church St., New York 7, New York

BOILERS FOR SALE

(2)—B&W 6700 sq. ft. heating surface, 670 H.P., design 200 PSI, operating 160 PSI, #4, buckwheat coal fired, chain stoker, installed 1941.

EASTERN SCRAP & SALVAGE CORP.
65 Muirhead Ave., Trenton, N. J.
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FOR SALE
MODERN POWER PLANT

2500 KVA GE Turbine Generator 3/60-2300/4160 volt, 400# 750° FTT, complete with boiler, superheater, economizer, condenser, boiler feed pump, feed water heater Hagan Combustion Control.

ELECTRIC EQUIP. & ENGR. CO.
Box 6597 Denver 16, Colo.

GUARANTEED REBUILT POWER EQUIPMENT

SLIP RING MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
2000	*G.E.	MT	257
1500	*Westg.	CW	900
1200	*Al.-Ch.	ANT	1800
600	*G.E.	MT	450
500	Westg.	CW	900
300	G.E.	IM-17B	900
252	*G.E.	IM	720
200	G.E.	IM	900
200	Westg. (2)	CW	514
200	*Westg.	CW-905A	514
150	Cr.-Wh.	50-R	1800
150	Westg.	CW	450
125	G.E. (2)	IM-15A	600
100	G.E.	IM-13A	1800
100	G.E.	MTC-5546	900
100	G.E.	IM	720
100	G.E.	IM	600
100	G.E.	IM-15A	450
75	G.E.	MT-347	1200
75	G.E.	IM	1200
75	Al.-Ch.	ARY-223C	1200
75	G.E.	MT-336	900
75	Al.-Ch.	ANY-26F	900
75	Al.-Ch.	ARY	720
75	G.E.	MT-352	720
75	G.E.	MT-536	720
75	G.E.	IM	600
60	Al.-Ch.	ARY	1200
60	G.E.	MT-546	1200
60	*G.E.	MT-536	1200
60	*Westg.	CW762C	900
50	Westg.	CW	1800
50	G.E.	IM-11A	1800
50	*Al.-Ch.	ARY	1200
50	Westg.	CW636A	1200
50	*G.E.	MT-536	1200

SLIP RING MOTORS

Crane & Hoist Service
3 phase, 60 cycle, 220 or 440 volts

H.P.	MAKE	TYPE	SPEED
80	G.E.	MTG-5532	600
75	Westg.	CI-756A	600
50	Westg.	MW-334	600
50	G.E.	HIC-TENV	600
35	G.E.	MTCV-5536	600
20	Westg.	CI	1200
11	Westg.	CI-E464	900
10	P & H	BW-6	1800
5	P & H	BW-6	1200
5	N. West.	WRC	1200
3	G.E.	MTC-5844	900

DYNAMOMETERS

250 VOLT DC WITH PANELS AND GRID RESISTORS

H.P.	MAKE	TYPE	SPEED
125	G.E. Cradle	TLC-20	2700/6000
150(3)	G.E. Cradle	TLC-50	2500/5000
200	Westg.-Block	SK-151	1350/4000

PLATERS

AMPS.	MAKE	VOLTS
7500/3750	Elec. Prod.	6/12—220/440
2000/1000	Chandy.	6/12—220/440
1500/750	Chandy.	12/24—220/440
1500/750	Chandy.	6/12—220/440
1000/500	Chandy.	12/24—220/440

SQUIRREL CAGE MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
1250	*Al-Ch. (3)	ANX	3600
1200	*Al-Ch.	ARW	1200
750	*Westg.	CS	900
500	*Al-Ch.	ARW	3600
500	*G.E.	KT5698	900
500	G.E.	KT-424	450
350	*G.E.	KT-559A	1800
250	Westg.	CS-8120S TEFC	1800
250	G.E. (2)	KT-558	1800
250	*L-Allis	OEX-148	720
250	*G.E.	IK	600
250	G.E.	IK-17A	600
250	Westg.	CS-14	514
200	*G.E.	FT-549Y	3600
200	*G.E.	IK-13B	1800
200	G.E.	KT-564	900
200	*Westg.	CS-930A	900
200	G.E. (2)	KR-564S	720
200	Al-Ch.	ARWWT	600
150	G.E.	IE-13B	1200
150	*Al-Ch.	AN-30F	1200
150	G.E.	IK-15A	900
150	*Westg.	CS	600
125	Westg.	CS-771 Spnf	1800
125	*Al-Ch.	AR	1800
125	Westg. (2)	CS-761S	1750
125	Cr. Wh. (2)	Size 5QR	1200
125	*Reliance	AA 6085	900
123	Al. Chal.	AN	514
100	Westg.	CS5075 TEFC	3600
100	*Westg.	CS-760A	1800
100	*G.E.	FT-542Z	1800
100	G.E.	FTRP-543	1800
100	*Westg.	CS-760D	1200
100	G.E.	KT-553	1200

D. C. MOTORS

H.P.	MAKE	TYPE	SPEED
250	Westg.	SK-220	450/600
200	Reliance (2)	1400T	350/1200
200	Westg.	SK-201	650
200	Cr. Wh.	CM	500
175	G.E.	ELC	750
100	G.E.	MPC	400/800
100	G.E.	RC-34	2500
100	G.E.	RC-10	575
100/150	G.E.	MCF	330/1000
50	Cr. Wh.	CMC	700/1100
35	Westg. (2)	SK150	350/1000
30	Cr. Wh.	CCM-504	450
30/40	G.E. (2)	CD-123	400/1600
30/40	G.E.	CD-115	500/1500
25/30	G.E. (2)	RF-12	500/1500
25	G.E.	RC-32	800
25	Westg.	SK-133	575
20/25	Westg.	SK-151L	250/1000

M.G. SETS

K.W.	MAKE	A.C.	D.C.
1250	Westg.	6600/4160	600
1000	G.E.	12000	600
500	Westg.	2300	125/250
400	A.C.	2300	120/240
300	Westg.	2300/440	250
250	G.E.	2300	250/275
200	Westg.	2300/4000	250/275
200	Ridgeway	2300	250
170	G.E.	440	125
150	G.E.	2300	125/250
150	A.C.	2300	275
150	Westg.	2300	125
150	G.E.	440	275
125	Cr. Wh. (3)	4160	125
100	G.E.	2300	250
100	Al-Ch.	2300	250
100	Elec. Mch.	440	125

CHICAGO *Electric Co.*

1320 WEST CERMAK RD., CHICAGO 8, ILL.

BOILER FEED PUMPS

STEAM TURBINE DRIVEN

GPM	TFH	Stage	Mfg.
450	892	4	Worth. (2)
500	850	4	Worth.
200	1375	6	Ingersoll R. (2)
200	850	2	Weinman (2)
190	1320	4	De Laval
750	725	4	Worth. (2)

MOTOR DRIVEN

GPM	TFH	Stage	Mfg.
740	2250	5	Worth.
700	1550	6	Worth.
675	1100	5	LeCourtenay
500	1050	5	Worth. (3)
100	1150	5	Gould

UNDERWRITERS FIRE PUMP

GPM	TFH	Stage	Mfg.
1500	231	1 (motor driven)	Fairbanks
750	231	(gas. driven)	Allis Chal. (2)

MOTOR DRIVEN SAND PUMPS

American Manganese 10"
Allen-Shaffer-Hoff 14"

NASH HYTOR COMPRESSORS

(4) size #2, 850 R.P.M., 10# pressure, 240 C.F.M.; 860 R.P.M., 180 C.F.M., when used as a Vacuum Pump.

2—2800 Gal. cap. 100# steam press. hot water storage heaters, mfg. by Quaker City Iron Works. Good shape.

This is only a partial listing of pumps carried in stock. We have hundreds of other pumps, compressors, and power equipment. Don't ask us what we have, write and tell us what you want.

PHILADELPHIA TRANSFORMER CO.
Box 566 Dalton, Pa.

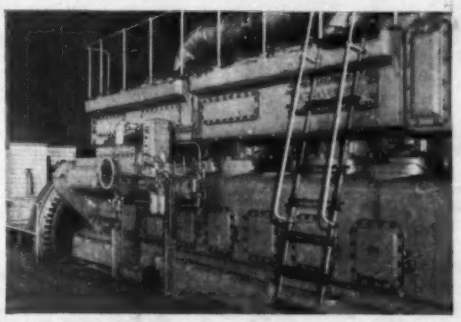
MODERN SLOW SPEED DIESEL ELECTRIC GENERATING SET

OFFERED AT CONSIDERABLE SAVING

FAIRBANKS MORSE

MODEL 33E16

1125 KW
300 RPM
3/60/480V



COMPLETE WITH ALL AUXILIARIES

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Other Sets from 20 KW to 1200 KW

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(3)—200 KW G.E. TYPE ATI, 3/60/450 Volts (with 40 KW D.C. exciter), gear driven, 1200/10012 RPM, 540/615 PSI, at 322° F, condensing (USED)
(3)—132 KW G.E. TYPE ATB, 3/60/450 Volts (with 40 KW, D.C. exciter) gear driven, 1200/10071 RPM, 540/615 PSI at 322° F, condensing (USED)

D.C. TURBO GENERATOR

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1—1000 KW—240 volts—130/250# Condensing Auto. Extraction—19#—New 1945
1—1000 KW 480 volts—225# Condensing Auto. Extraction—20#
1— 400 KW—550 volts—400# Condensing Auto. Extraction—20/50# New 1948
1— 300 KW—480 volts—210# Condensing Auto. Extraction—40#
1— 250 KW—240 volts—130#—Non-Cond. 10/12# Back pressure

TRANSFORMERS

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3— 500 KVA—2300/550 Volts (New 1948)
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1—120,000# Deaerating Heater—Tray Type

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THE BUYERS MUST BE SATISFIED—ALWAYS

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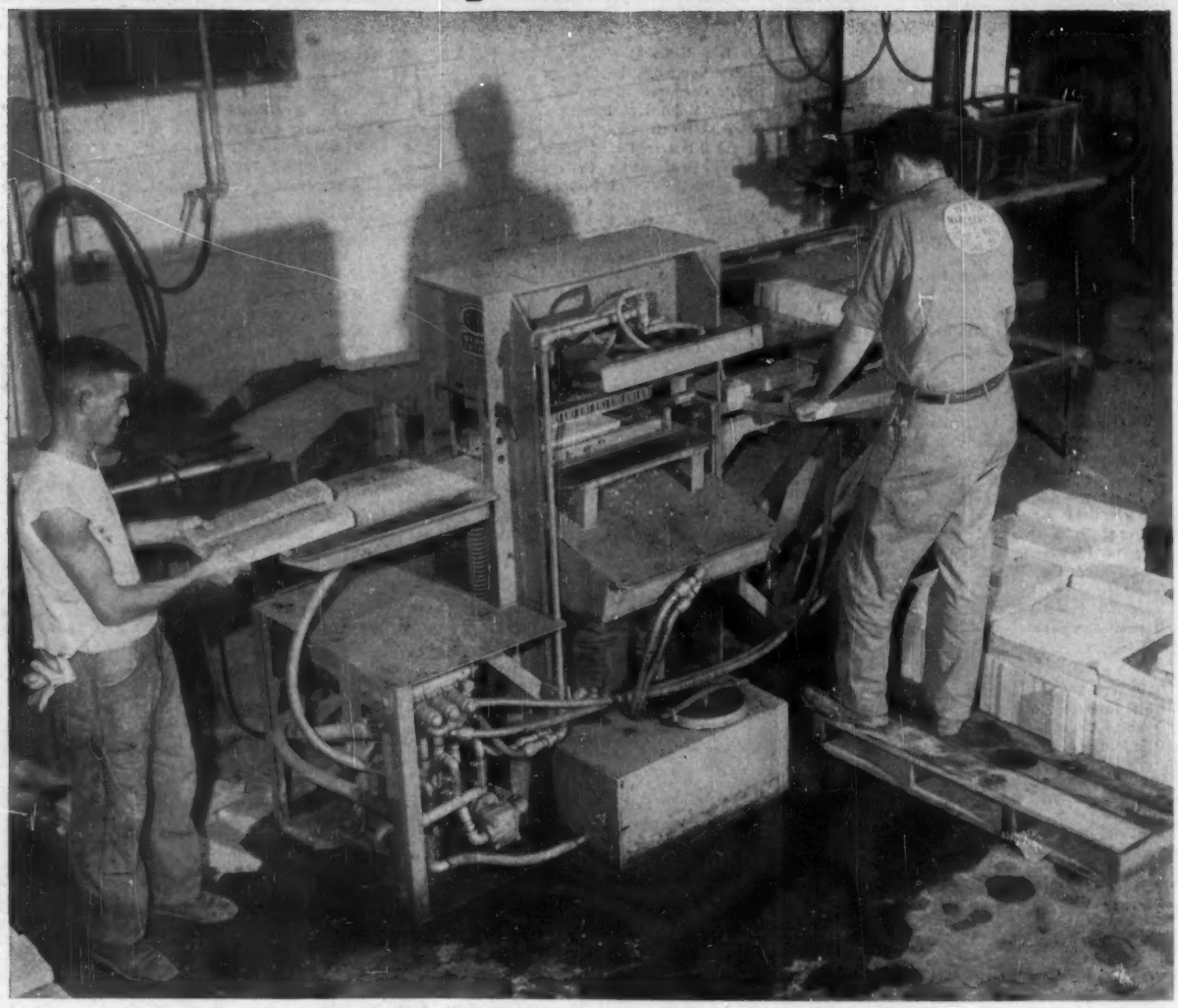

Machine cuts stone like paper

B. F. Goodrich improvements in rubber brought extra savings

Problem: This machine that cuts stone like a paper cutter is run by hydraulic power. Pressure as great as a ton for each square inch shoots through hydraulic lines.

Years ago, when hydraulic power was developed for all kinds of powerful machines, a flexible connection was needed. Rubber hose wasn't strong enough. Vibration wrecked metal tubing. For a while it seemed there would never be anything that would stand the sudden surges of hydraulic oil and still be flexible.

What was done: B. F. Goodrich engineers began experiments for stronger hose. They developed one that combines rubber for flexibility, steel for strength. Using steel wire, almost as fine as hair, they found a new way of braiding it, using a half mile of wire for every foot of rubber hose.

Savings: B. F. Goodrich hose has been in use on these stone-cutting machines over four years now, with no leaks, no bursts. So far as anyone knows the hose will last as long as the machines.

Extra benefits: B. F. Goodrich has made many other improvements. The tube is special to allow couplings to grip firmly, stay on longer without leaking. This kind of tube costs more to make but gives extra value far beyond cost.

Where to buy: Your B. F. Goodrich distributor has full information on these improvements, plus exact specifications on the hose described here. And, as a factory-trained specialist in rubber products, he *can* answer your questions about all the rubber products B. F. Goodrich makes for industry. *B. F. Goodrich Industrial Products Co., Dept. M-812, Akron 18, Ohio.*

B.F.Goodrich

INDUSTRIAL PRODUCTS

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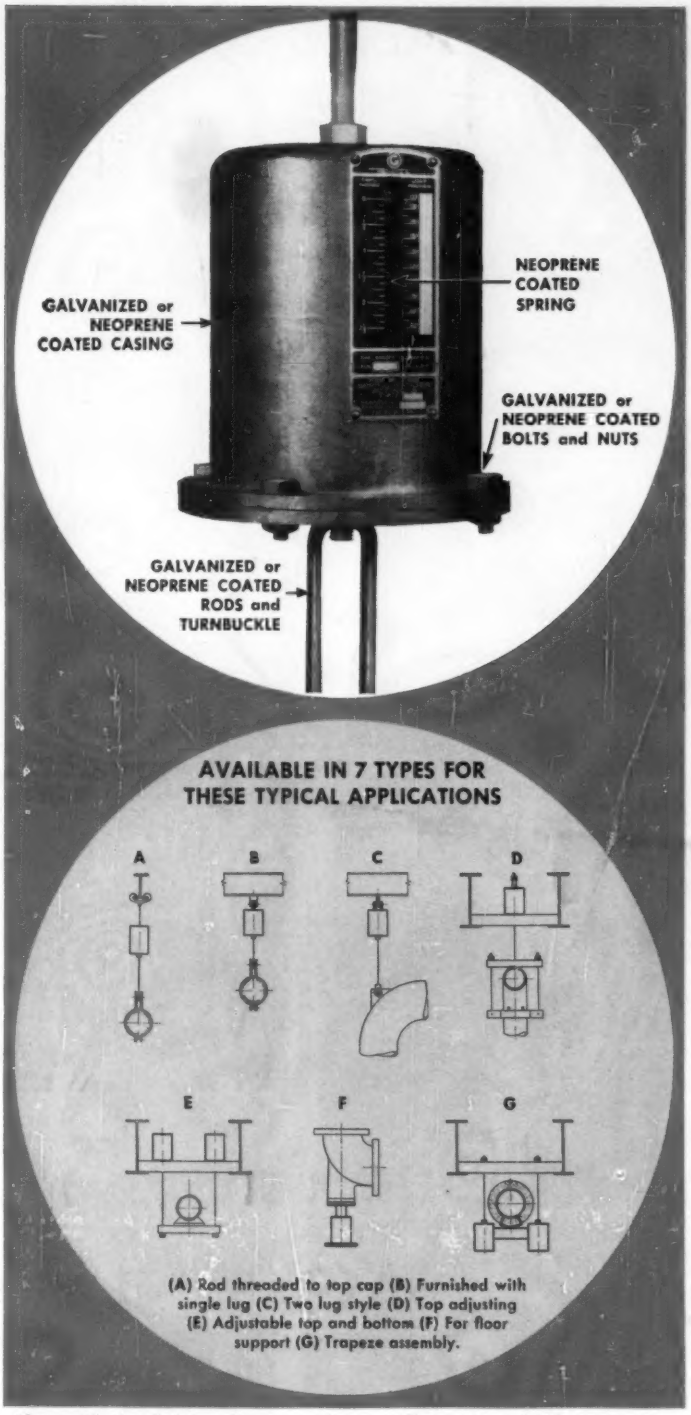
weather-resistant, corrosion-resistant GRINNELL VARIABLE SPRING HANGERS...


GALVANIZED or NEOPRENE COATED CASING
NEOPRENE COATED SPRING
GALVANIZED or NEOPRENE COATED BOLTS and NUTS
GALVANIZED or NEOPRENE COATED RODS and TURNBUCKLE
AVAILABLE IN 7 TYPES FOR THESE TYPICAL APPLICATIONS
A
B
C
D
E
F
G
(A) Rod threaded to top cap (B) Furnished with single lug (C) Two lug style (D) Top adjusting (E) Adjustable top and bottom (F) For floor support (G) Trapeze assembly.

Another Grinnell First!

Grinnell pre-engineered spring hangers are now offered in two new lines to meet the need for spring hangers in installations subject to highly corrosive industrial conditions and to severe weather exposure.

These hangers are the result of extensive experimentation with various coatings for Grinnell's standard pre-engineered spring hangers. In addition to providing flexibility in pipe suspension, they provide versatility of application through their corrosion-resistant characteristics. They are . . .

1. Neoprene coated — for highly corrosive conditions such as those found in chemical plants and refineries. *All* parts of the hanger are neoprene coated to protect the base metal from a wide range of corrosives. The flex life of the spring is unaffected by the neoprene . . . the coating resists cracking or flaking over a wide temperature range.

2. Galvanized — for outdoor installations where weather conditions are severe. All parts of the hanger are galvanized except the spring, which is neoprene coated to avoid alteration of temper, hydrogen embrittlement and decreased flex-life of the spring — usual hazards to springs from the galvanizing process.

Along with the obvious advantages of such corrosion and weather-resistant characteristics, consider these features...

- Maximum variation in supporting force per ½" of deflection is 10½% of rated capacity — in all sizes.
- Precompression* assures operation of spring within its proper working range, as well as saving valuable erection time. Reduced over-all height saves space.
- 18 sizes available from stock for load ranges from 53 lbs. to 12,000 lbs.
- Available in 3 spring lengths for travel ranges of 1¼, 2½, and 5 inches.
- Installation is simplified by integral load scale and travel indicators.

*Precompression is a patented feature.

GRINNELL

AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

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pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
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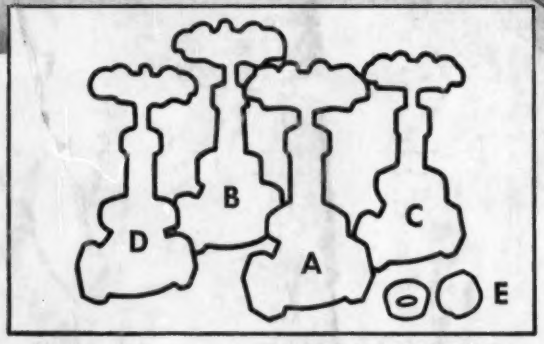

A — No. 225P.....350 WSP 550F, 1000 WOG
B — No. 260P.....300 WSP 550F, 600 WOG
C — No. 245P.....200 WSP 550F, 400 WOG
D — No. 237P.....150 WSP 500F, 300 WOG
E — "500 Brinell" Stainless Steel Plug Type Seat and Disc

Walworth offers four lines of Bronze Globe Valves with stainless steel, plug-type seats and discs. Advantages of these valves include:

• **Stainless Steel Plug-Type Seats and Discs,** heat-treated to a minimum of 500 Brinell hardness reduces wire-drawing to a minimum. Seats and Discs are machined and fitted simultaneously, assuring perfect mating.

• **Deep Stuffing Boxes with Glands** are fitted with reinforced, molded packing. Valves can be repacked under pressure when fully opened.

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"500 BRINELL" PLUG-TYPE STAINLESS STEEL SEATS AND DISCS

150 lb. 200 lb. 300 lb. 350 lb.

• **Oversize Stems,** made of high tensile strength silicon-bronze, assure long life.

• **Rugged Body Hexes,** are flat on top; do not interfere with wrench gripping body-to-bonnet union ring connection.

• **Bodies,** made of Composition M bronze (ASTM B61), have ample wall thickness to provide high safety factor.

• **Patented Handwheels** are air-cooled and designed with a "finger-fit grip." Makes turning easy even when wearing greasy gloves.

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FOR COMPLETE INFORMATION, SEE YOUR WALWORTH DISTRIBUTOR OR WRITE FOR ILLUSTRATED CIRCULAR

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